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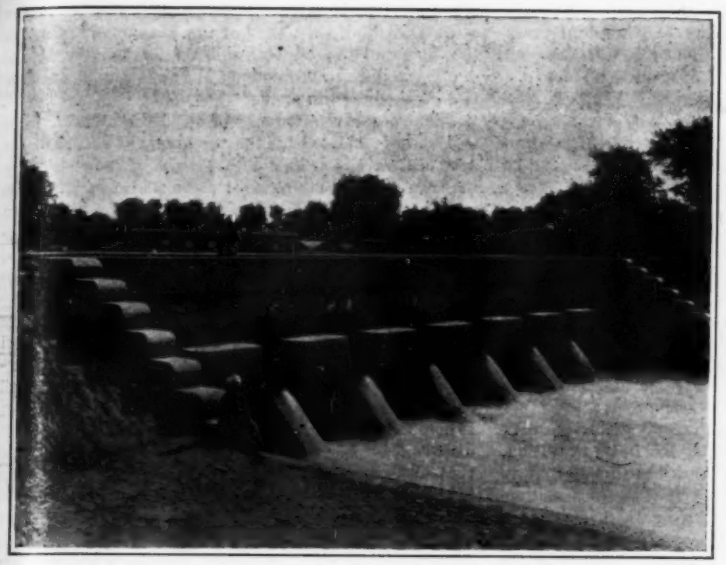
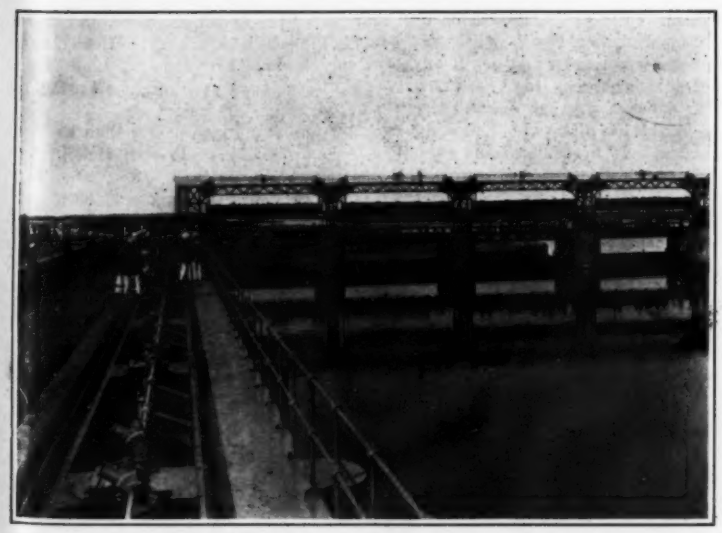


Fall at R. D. 37,000 Jhang branch of the lower Chenat Canal.

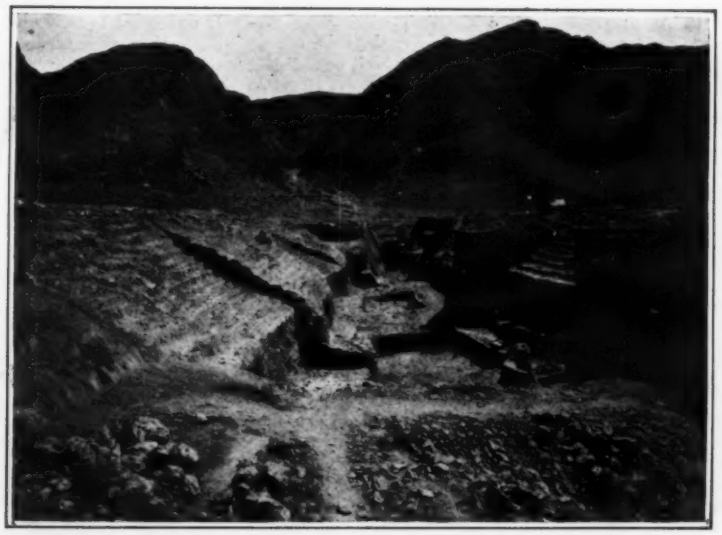
Bird's eye view of the undersluices and weir, Lower Chenat Canal.

Inlet of Upper Bari Doab Canal.

Rapid No. 3 on the Upper Bari Doab Canal.



View of barrage, Lower Bari Doab Canal.



Head of the tunnel near Katlang, Machai branch Upper Swat Canal.

IRRIGATION WORKS OF INDIA.—[See page 164.]

Measurement of the Distances of the Stars—I*

A Review of Early Efforts and a Discussion of Modern Methods

For the lecture in honor and memory of Edward Halley, which it is my privilege to deliver this year, I have chosen an account of the persistent efforts made by astronomers to measure the distances of the fixed stars. For many generations their attempts were unsuccessful, though some of them led to great and unexpected discoveries. It is less than eighty years ago that the distances of two or three of the nearest stars were determined with any certainty. The number was added to, slowly at first, but afterward at a greater rate, and now that large telescopes are available and photographic methods have been developed, we may expect that in the next few years very rapid progress will be made.

For many centuries astronomers had speculated on the distances of the stars. The Greeks measured the distance of the moon; they knew that the sun and planets were much farther away, and placed them correctly in order of distance, guessing that the sun was nearer than Jupiter because it went round the sky in one year while Jupiter took twelve. The stars, from their absolute constancy of relative position, were rightly judged to be still more distant—but how much more they had no means of telling.

In 1543 Copernicus published "De Revolutionibus Orbium Cœlestium," and showed that the remarkable movements of the planets among the stars were much easier to understand on the hypothesis that the earth moved annually round the sun. Galileo's telescope added such cogent argument that the Copernican system was firmly established. Among other difficulties which were not cleared up at the time one of the most important was this: If the earth describes a great orbit round the sun, its position changes very greatly. The question was rightly asked: Why do not the nearer stars change their positions relatively to the more distant ones? There was only one answer. Because they are so extremely distant. This was a hard saying, and the only reply which Kepler, who was a convinced believer in the earth's movement round the sun, could make to critics was "Boluserat devorandus."

Although no difference in the positions of the stars were discernible to the naked eye, it might be that smaller differences existed which could be detected by refined astronomical measurements. To the naked eye a change in the angle between neighboring stars not more than the apparent diameter of the sun or moon should be observable. No such changes are perceived. The stars are—it may be concluded—at least two hundred times as distant as the sun. With the instruments in use in the seventeenth century—before the telescope was used for the accurate measurement of angles—angles one-twentieth as large were measurable, and the conclusion was reached that the stars were at least four thousand times as distant as the sun. But no positive results were obtained. Attempts followed with the telescope and were equally unsuccessful. Hooke tried to find changes in the position of the star γ Draconis and failed. Flamsteed, Picard, and Cassini made extensive observations to detect changes in the position of the pole star and failed. Horrebow thought he had detected slight changes in the position of Sirius due to its nearness in a series of observations made by Romer. He published a pamphlet, entitled "Copernicus triumphans," in 1727, but the changes in the position of Sirius were not verified by other observers, and were due to slight movements of Romer's instruments.

Thus in Halley's time it was fairly well established that the stars were at least 20,000 or 30,000 times as distant as the sun. Halley did not succeed in finding their range, but he made an important discovery which showed that three of the stars were at sensible distances. In 1718, he contributed to the Royal Society a paper entitled "Considerations on the Change of the Latitude of Some of the Principal Bright Stars." While pursuing researches on another subject, he found that the three bright stars—Aldebaran, Sirius, and Arcturus—occupied positions among the other stars differing considerably from those assigned to them in the Almagest of Ptolemy. He showed that the possibility of an error in the transcription of the manuscript could be safely excluded, and that the southward movement of these stars to the extent of 37 seconds, 42 seconds, and 33 seconds—i. e., angles larger than the apparent diameter of the sun in the sky—were established. He remarks:

"What shall we say then? It is scarce possible that the ancient could be deceived in so plain a matter, three observers confirming each other. Again these stars being the most conspicuous in heaven are in all probability nearest to the earth, and if they have any particular motion of their own, it is most likely to be perceived in them, which in so long a time as 1,800 years may show itself by an alteration of their places, though it be utterly imperceptible in a single century of years."

This is the first good evidence, i. e., evidence which we now know to be true, that the so-called fixed stars are not fixed relatively to one another. It is the first positive proof that the distances of the stars are sensibly less than infinite. This, then, is the stage at which astronomers had arrived less than two hundred years ago. The stars are at least 20,000 or 30,000 times as distant as the sun, but three of the brightest of them are perceived to be not infinitely distant.

The greatest step in the determination of stellar distances was made by another Oxford astronomer, James Bradley. His unparalleled skill as an astronomer was early recognized by Halley, who tells how "Dr. Pound and his nephew, Mr. Bradley, did, myself being present, in the last opposition of the sun and Mars this way demonstrate the extreme minuteness of the sun's parallax, and that it was not more than 12 seconds nor less than 12 seconds." Translated from astronomical language, the distance of the sun is between 95 and 125 millions of miles. Actually the distance is 93 million miles. The astronomer who so readily measured the distance of the sun entered on the great research which had baffled his predecessors—the distance of the stars.

The theory of the determination of stellar parallax is very simple: the whole difficulty lies in its execution, because the angles are so small that the slightest errors vitiate the results completely. Even at the present time with large telescopes, and mechanism which moves the telescope so that the diurnal movement of the stars is followed and they appear fixed to the observer in the field of the telescope, and with the additional help of photography, the determination of the parallax of a star requires a good deal of care, and is a matter of great delicacy. But in Bradley's time telescopes were imperfect, and the mechanism for moving them uniformly to follow the diurnal rotation of the stars had not been devised.

This was in some ways very fortunate, as the method Bradley was forced to adopt led to two most important and unexpected discoveries. Every day, owing to the earth's rotation, the stars appear to describe circles in the sky. They reach the highest point when they cross the meridian or vertical plane running north and south. If we leave out all disturbing causes and suppose the earth's axis is quite fixed in direction, a star S, if at a great distance from the earth, will always cross the meridian at the same point S; but, if it is very near, its movement in the small parallactic ellipse will at one period of the year bring it rather north of its mean position and at the opposite period an equal amount south.

Bradley, therefore, designed an instrument for measuring the angular distance from the zenith, at which a certain star, γ Draconis, crossed the meridian. This distance measurement instrument is called a zenith sector. The direction of the vertical is given by a plumb-line, and he measured from day to day the angular distance of the star from the direction of the vertical. From December, 1725, to March, 1726, the star gradually moved farther south; then it remained stationary for a little time; then moved northward until, by the middle of June, it was in the same position as in December. It continued to move northward until the beginning of September, then turned again and reached its old position in December. The movement was very regular and evidently not due to any errors in Bradley's observations. But it was most unexpected. The effect of parallax—which Bradley was looking for—would have brought the star farthest south in December, not in March. The times were all three months wrong. Bradley examined other stars, thinking first that this might be due to a movement of the earth's pole. But this would not explain the phenomena. The true explanation, it is said, although I do not know how truly, occurred to Bradley when he was sailing on the Thames, and noticed that the direction of the wind, as indicated by a vane on the mast-head, varied slightly with the course on which the boat was sailing. An account of the observations in the form of a letter from Bradley to Halley is published in the *Philosophical Transactions* for December, 1728:—

"When the Year was completed, I began to examine and compare my Observations, and having pretty well satisfied myself as to the general Laws of the *Phenomena*, I then endeavored to find out the Cause of them. I was already convinced that the apparent Motion of the Stars was not owing to a Nutation of the Earth's Axis. The next thing that offered itself, was an Alteration in the Direction of the Plumb-line, with which the instrument was constantly rectified; but this upon trial proved insufficient. Then I considered what Refraction might do, but here also nothing satisfactory occurred. At last I conjectured that all the *Phenomena* hitherto mentioned, proceeded from the progressive Motion for Light and the Earth's Annual Motion in its Orbit. For I perceived that, if Light was propagated in Time, the apparent Place of a fixed Object would not be the same when the Eye is at Rest, as when it is moving in any other Direction, than that of the Line passing through the Eye and the Object; and that, when the Eye is moving in different Directions, the apparent Place of the Object would be different."

This wonderful discovery of the Aberration of Light is usually elucidated by the very homely illustration of how an unbrella is held in a shower of rain. Suppose the rain were falling straight down and a man walking round a circular track: he always holds the umbrella a little in front of him—because when he is walking northward the rain appears to come a little from the north, when he is going eastward it appears to come a little from the east, and so on.

Although the phenomena Bradley had observed were almost wholly explained in this way, there were still some residual changes, which took nineteen years to unravel; and he explained these by a nutation or small oscillation of the earth's axis, which took nineteen years to complete its period. I cannot dwell on these two great discoveries. For our present purpose, it should be said that aberration and nutation cause far greater changes in the apparent positions of the stars than, we now know, are caused by parallax. Until they were understood and allowed for or eliminated, all search for parallax must have been in vain. Further, Bradley's observations showed that in the case of γ Draconis, at any rate, parallax did not displace the star by so much as 1.0 second from its mean position, or that the star was 200,000 times as distant as the sun. We may say that Bradley reached to just about the inside limit of the distances of the nearer stars.

Let me now try to give some idea of what is meant by a parallax of 1 second, which corresponds to a distance 200,000 times that of the sun. Probably many of you have looked at the second star in the tail of the Great Bear, Mizar, it is named, and have seen there is a fainter star near it, which you can see nicely on a fine night. These stars are 600 seconds apart; with a big telescope with a magnification of 600 times—and this is about as high a magnification as can be generally used in England—two stars 1 second apart are seen double just as clearly as Alcor and Mizar are seen with the naked eye. I think this is the most useful way to think of 1 second—a very small angle, which one needs a magnification of 600 times to see easily and clearly. Bradley showed that γ Draconis did not wander by this amount from its mean position among the stars in consequence of our changing viewpoint.

The next attempt to which I wish to refer is the one made by Sir William Herschel. In a paper communicated by him to the Royal Society in December, 1781, he reviews the serious difficulties involved in determining the parallax of a star by comparing its zenith distance at different times of the year. Especially there is the uncertainty introduced by the refraction of light, and in addition as the angular distances of stars from the zenith are changed by precession, nutation, and aberration, any errors in the calculated amount of these changes will all affect the results. He proposed, therefore, to examine with his big telescope the bright stars and see which of them had faint stars near them. The bright stars, he said, are probably much nearer than the faint stars; and if the parallax does not even amount to 1 second the case is by no means desperate. With a large telescope of very great perfection it should be possible to detect changes in the angular distance of two neighboring stars. By this differential method the difficulties inherent in the method of zenith distances will be eliminated. Herschel made a great survey to find suitable stars, and in this way was led to the discovery of double stars—i. e., of pairs of stars which are physically connected and revolve around one another, just like sun and earth. This was a most important discovery, but as the two components of a double star are practically at the same distance from us they do not serve to determine parallax, for which we need one star to serve as a distant mark.

For another forty years persistent efforts were made without success. Piazzi, in Italy, thought he had detected parallax in Sirius and a number of other bright stars, but the changes he detected in the zenith distances were unquestionably due to errors introduced by uncertainty in refraction, or slight changes in the position of his instruments in the course of the year. Dr. Brinkley,

*The "Halley Lecture" (slightly abridged), delivered at Oxford by Sir F. W. Dyson, F. R. S., Astronomer Royal, from *Nature*.

in Dublin, made a gallant effort and took the greatest pains. He thought he had succeeded, and for many years there was a controversy between him and Pond as to whether his results were trustworthy. The state of knowledge of the distances of the fixed stars in 1823 is summed up accurately by Pond in the *Philosophical Transactions:*—

"The History of annual parallax appears to me to be this: in proportion as instruments have been imperfect in their construction, they have misled observers into the belief of the existence of sensible parallax. This has happened in Italy to astronomers of the very first reputation. The Dublin instrument is superior to any of a similar construction on the Continent; and, accordingly it shows a much less parallax than the Italian astronomers imagined they had detected. Conceiving that I have established, beyond a doubt, that the Greenwich instrument approaches still nearer to perfection, I can come to no other conclusion than that this is the reason why it discovers no parallax at all."

Besides these and other efforts to find parallax in the zenith distances of stars, attempts were also made to detect changes in the time at which the stars cross the meridian, to see if they are slightly before their time at one period of the year and slightly after it at another. But these, too, were unsuccessful, even in the hands of astronomers like Bessel and Struve. The best were some observations of circumpolar stars made by Struve in Dorpat between 1814 and 1821. The following table shows some of the results at which he arrived:—

		"	"
Polaris and ε Urs. Maj.	$\pi + 0.053\pi'$	=	$+0.075 \pm 0.034$
ε Urs. Maj. and α Cass.	$\pi + 0.962\pi'$	=	-0.136 ± 0.110
ζ Urs. Maj. and δ Cass.	$\pi + 1.099\pi'$	=	$+0.175 \pm 0.127$
β Urs. Min. and α Persei	$\pi + 0.402\pi'$	=	$+0.305 \pm 0.071$
Capella and β Drac.	$\pi + 1.147\pi'$	=	$+0.134 \pm 0.139$
β Aurig. and γ Drac.	$\pi + 1.138\pi'$	=	$+0.020 \pm 0.117$

This table has the merit of not looking wildly impossible in the present state of our knowledge. It has the disadvantage of not giving a definite parallax to each star. For example, it is impossible to say how much of the 0.134 second is to be given to Capella and how much to β Draconis. Further, the probable errors, though really small, are nearly as large as the quantities determined.

Struve and Bessel, therefore, attempted the problem by the differential method recommended by Herschel. By this time it had become easier to carry out. The method of mounting telescopes equatorially had been devised, so that the telescope was always kept pointing to the same part of the sky by clockwork-driven mechanism. Struve chose the bright star α Lyræ, and measured its distance from a faint star about 40 seconds away on ninety-six nights between November, 1835, and August, 1838. In the focal plane of his telescope he had what is called a position micrometer. The micrometer contains two parallel spider-threads stretched on frames, and the frames are movable by screws until the position shown in the diagram is reached: the distance apart of the threads is known by the readings of the screw-heads. He found that α Lyræ had a parallax 0.262 second with a probable error ±0.025 second.

Bessel chose the star 61 Cygni as a likely star to be near the sun, and, therefore, to have appreciable parallax. 61 Cygni is not nearly so bright as α Lyræ, but has a very great angular movement or proper-motion among the stars. Bessel used an instrument called a heliometer. Like Struve's telescope, it was mounted so that it could be driven by clockwork to point always at the same star. The object-glass of Bessel's telescope was made by the great optician Fraunhofer, with the intention of cutting it in halves. Fraunhofer died before the time came to carry out this delicate operation, but it was successfully accomplished after his death.

Delicate mechanism was provided for turning the glass, and, also, for moving the two halves, the amount of movement being very accurately measured by screws. Each half gives a perfect image of any object which is examined, but the two images are shifted by an amount equal to the distance one half of the lens is moved along the other. Thus, when a bright star and faint star are looked at, one half of the object-glass can be made to give images S and s, and the other half S' and s'. By moving the screw exactly the right amount s' can be made to coincide with S, and the reading of the screw gives a measure of the angular distance between the two stars. Bessel made observations on ninety-eight nights extending from August, 1837, to September, 1838. The table, top of second column, taken from a report by Main (Mem. R. A .S., vol. xii.,p. 29), shows how closely the mean of the observations for each month accords with the supposition that the star has the parallax 0.369 second.

Simultaneously with these determinations of the distance of α Lyræ and 61 Cygni, the distance of α Centauri, one of the brightest of the southern stars, was found by Henderson from observations of zenith distance made by him at the Cape between April, 1832, and May, 1833. He learnt just before the termination of his residence at the Cape that this star had a very large proper-motion.

Mean date.	Observed displacement.	Effect of parallax 0".369
1837.	"	"
August 23rd	+0.197	+0.212
September 14th	+0.100	+0.100
October 12th	+0.040	−0.057
November 22nd	−0.214	−0.258
December 21st	−0.322	−0.317
1838.		
January 14th	−0.376	−0.318
February 5th	−0.223	−0.266
May 14th	+0.245	+0.238
June 19th	+0.360	+0.332
July 13th	+0.216	+0.332
August 19th	+0.151	+0.227
September 19th	+0.040	+0.073

Suspecting a possible parallax he examined the observations when he had taken up his new office of Astronomer Royal for Scotland and found a parallax amounting to 0.92 second. He did not, however, publish his results until he found that they were confirmed by the right ascensions. In a communication to the Royal Astronomical Society in December, 1838, he states that it is probable that the star has a parallax of 1.0 second.

The great and difficult problem which had occupied astronomers for many generations was thus solved for three separate stars in 1838:—

	Parallax	Distance	Modern Observations	
			Parallax	Distance
	"		"	
α Centauri (Henderson)	1.0	200,000	0.750	270,000
61 Cygni (Bessel)	0.314	640,000	0.285	700,000
α Lyræ (Struve)	0.262	760,000	0.10	2,000,000

(The unit of distance is that from the earth to the sun.)

Henderson's observation is interesting because α Centauri is, as far as we yet know, the nearest of all the stars to us. But by far the most valuable of these observations is Bessel's. The heliometer, which he devised, proved to be by far the most serviceable instrument for determining stellar parallax until the application of photography for his purpose.

The somewhat dramatic manner in which the distances of three stars were determined in the same year, after several centuries of failures, may have led to the hope that the range of many more stars would soon be found. This was not the case, however. Each star had to be measured separately, and involved many nights of observations. The quantities to be measured were so small that they taxed the resources of the best instruments and best observers. In 1843, Peter published the parallaxes of half a dozen stars determined with the vertical circle at Pulkova, but the parallax of only one of these, Polaris, is obtained with much accuracy. With Bessel's heliometer, Schlüter and Wichmann measured the distance of Gr. 1830, the star which had the largest known proper-motion. In the 'sixties, Auwers with the same instrument determined the parallax of several quick-moving stars, and, also, of the bright star Procyon. With the Bonn heliometer, Krueger in the 'sixties measured the distance of three stars, and Winnecke two more. Other observations were made, among others, by Maclear, Otto Struve, Brünnow, and Ball; but as these observers had not such suitable instruments, their results were not of the same high standard of value. A generous estimate would place the number of stars the distances of which had been satisfactorily determined before 1880 at not more than twenty.

(*To be concluded.*)

Technical Utilization of Precious Stones

HERRMAN WILD, in Idar, Germany, working with Professor Miethe in Berlin, has been performing experiments in the production of artificial precious corundum stones on a commercial scale. Experiments in this direction had been made by others ever since the middle of the nineteenth century. The process is based on a well-known principle of crystal formation, the procedure being to add a crystal of the substance (sapphire or ruby) to a drop of a mixture of identical chemical composition, which has previously been melted. The crystal grows regularly, just as it grew from the solution of the substance from which it was originally formed. The stone is made by melting a minute amount of aluminium oxide placed on a refractory base by means of an oxyhydrogen flame directed vertically against it, and by automatic arrangement adding exceedingly minute quantities of the aluminium oxide, carried in the stream of oxygen. The original crystal increases greatly in size.

The precious corundum stones made in this way look like small stalactites, and show only a few mirror-like crystalline faces; but they are single crystals, and are in every respect identical with the crystals found in nature and cannot be distinguished from them. They have the same specific gravity, the same optical and crystallographic properties. They are not imitations of the genuine stones, but are identical with them. The coloring of the synthetic stones exactly like the natural ones, is brought about by the addition of metallic compounds, generally compounds of chromium or iron added to the aluminium oxide. A company has been organized, called the Deutsche Edelstein Gesellschaft in Idar, for the manufacture and coloring of these gems.

Since these synthetic stones differ from natural ones only in that they are purer, more regular, and free from flaws, their use as gem stones can only be objected to on the wrong assumption that the value of a stone for gem purposes is determined solely by its price.

Technical workers have quickly recognized the value of these synthetic stones for use in the manufacture of fine appliances and mechanisms; it has only been ten years since these gems were first made, and their use in industry is increasing.

The watchmakers were the first to adopt them, using them for jeweled bearings. The increase of the use of natural gem stones for this purpose in the watch industry and the consequent rise in price of good natural rubies, has made it impossible to use anything but poor, colorless stones that are difficult to work, although the price of the watch is greatly increased. The cost of the jewels is an important factor in the price of the watch itself.

The synthetic ruby, with the desired dark coloring, uniformity in structure and hardness, and freedom from flaws and impurities, can be produced at a smaller price than the less valuable natural stones, even the smaller ones. It is only natural to expect them to be used largely. Indeed there are three or four million karats used annually for watch jewels.

The use of artificial gem stones in the manufacture of electrical apparatus is also increasing greatly. These stones were found on careful investigation to resist the action of acids and heat to a much greater extent than the natural ones. They are used in the form of plates, cylinders, rods and prisms as bearings for electrical measuring apparatus of various kinds. The price of the larger artificial stones used for this purpose, as compared with that of large natural stones, is very small; on account of this small cost and the durability of the synthetic stones, their use has increased to such an extent that two million karats have been used per annum in Germany alone.

The stones are also used as a material for draw-plates in the manufacture of filaments for incandescent lamps. Their hardness and resistance to heat is so great that they have replaced the very expensive synthetic diamonds formerly used for this purpose.

These rubies and sapphires are also used in the manufacture of compasses and similar instruments and in optical apparatus. They have been used also for bearings for high-speed motors, where great strength and resistance to high temperature is necessary.

The larger stones are much cheaper than natural ones of the same size. For example, a synthetic ruby of 6 millimeters in diameter costs only one fourth or one fifth as much as a natural ruby of the same quality.

During the present war, the supply of natural gem stones from India, Ceylon and Australia has been cut off, so that, were it not for these synthetic corundum stones a supply of gems for personal adornment and for fine bearings of technical instruments would not be available.

Working the Chickens Overtime.

A RESIDENT of Chicago is reported to have devised a way to keep his chickens up to their work during the winter season, when the short days have an undesirable effect on the production of eggs. His plan is to provide his chickens with artificial light to work by, and he has installed a series of electric lights in his hen house. This is the way he works his scheme, according to the *Electrical Review:*

"At six in the morning I turn on the switch, and the fowls get up, thinking it is daylight. The lights are turned off at daylight, when the neighbors' fowls are just arising. At four the lights are turned on again, and they are kept going until nine at night, when I turn out all except the 2 candle-power lamps. These give just sufficient light to give the appearance of dusk, and the fowls begin going to roost. I leave the small lamps lit all night, so that if any of the fowls want to get up at night to eat they can do so. Eleven days after the lights were installed the daily average jumped from twenty-six eggs to eighty-three. During the moulting season under the old custom, when most of the food was going to feathers instead of eggs, I had only eleven eggs a day. Now I get fifty-two a day during the moulting season. By my method I keep the chickens thinking they are getting the same amount of daylight all the year round, and I am keeping them thinking all the time."

The Irrigation Works of India

Vast Engineering Schemes by Which the Dreaded Famine Scourge Has Been Wiped Out

By H. J. Shepstone

"It is a notorious fact," said the President of the London Institution of Civil Engineers the other day, "that the great irrigation works of India are seldom heard of, and I cannot but think that the magnitude of some of them is but little appreciated even by members of our own profession." This apparent lack of knowledge as to what the engineer has done, and is still doing, in reclaiming the arid wastes of India, is undoubtedly due to the fact that the work is carried out by the Government, by Government engineers, with the result that little mention is made of the undertakings.

Yet there is no country in the world where the irrigating engineer has accomplished such wonders, and has been called upon to fight such stirring battles against the forces of Nature as in India. Here he has built dams greater than those to be found on the Nile, and miles of canals or artificial waterways as wide as some of the world's most famous rivers. Furthermore, the irrigating engineer has successfully fought the famine scourge, and thus saved millions of lives. Indeed, India is indebted far more to the labor of the civil engineers for her prosperity to-day than to those of any other body of men whatever.

To appreciate fully the work of these brave men, a few details about this wonderful country are essential. India, including the native States, occupies an area of 1,773,000 square miles, about equal to that of Europe, omitting Russia, or more than ten times as large as that of the State of California. Upon this territory there dwells a population of 316,000,000 souls, over three times as many as in the whole of the United States. In the famine of 1769–70, 3,000,000 people perished. The air was so infested by the noxious effluvia of dead bodies that it was scarcely possible to stir abroad without noticing it. From 1770 to 1790, not a year passed without a portion of this large empire being smitten with famine, more or less of a serious nature. The year 1866 witnessed an awful famine in the lower provinces of Bengal, Orissa, and Behar, when over 1,500,000 people perished. The Bengal famine of 1874 carried off a million human beings, while a like number perished in the famine of 1877. In the famine of 1896–97, no fewer than 2,500,000 died; while the death-roll of the terrible famine of 1900 reached over three millions. In that year, owing to the failure of the rains, 85,000,000 people were brought to the verge of starvation.

This is the evil which the irrigating engineer has set out to combat; and how well this scourge is being fought is evidenced when it is stated that the Government alone has sunk $190,000,000 in irrigation work, which has meant the reclamation of 22½ million acres of desert land. But it has been money well spent, yielding a return on the capital invested of 7 per cent. And it has not been a question of making two blades of corn grow where one did before, but of growing corn and rice and sugar where, without irrigation, the land would be a desert.

When it is stated that 65 per cent of the population of this vast country are engaged in agriculture it will be seen how important the question of suitable irrigation becomes. But unfortunately for the engineer, however, all kinds of irregular conditions exist, the principals of which are the extremely variable character of the rainfall, the character of the soil, and the nature of the crops to be raised. The average rainfall for the whole of India is 42 inches in the year; that is, 42 inches would be the depth of rain water if it were distributed equally over the entire country, but the fluctuation is very varied, the extremes being represented by 5 inches in some cases and by nearly 500 inches in others.

But quite apart from the question of rainfall other problems enter into any irrigation scheme. There is the nature of the soils. These comprise, in some districts, vast alluvial tracts of yellow loam, clay, and sands; in others, the black cotton soils of the Deccan trap, where cotton is mostly grown; in others, again, the crystalline and sandstone formations occur. Crops, too, differ greatly in the extent of their need of irrigation. Cotton does not ordinarily require any irrigation, and very little even in years of drought. Barley only wants irrigation in a dry year, but wheat requires a good supply, as does sugar-cane, and rice takes most of all. It is estimated that 1,000,000 cubic feet of water are required to irrigate six to eight acres of rice field, and a third of that quantity for wheat. Other crops are millet, jute, gingelly, indigo, linseed; some of these are Spring crops, others Autumn, and all require suitable soils and varying amounts of irrigation.

Then, again, besides the character of the soil and crops, the natural dispositions of the land determine what kind of irrigation must be adopted. There are three great systems: canals, tanks, and wells. If we include the irrigation schemes which have been carried out by the ruling princes in the various native States, and by private enterprise, we find that there are now 53 million acres of irrigated land in India, an artificially watered territory about equal to the total area of Florida. Of this, 19,000,000 acres are irrigated by canals, 16,000,000 from wells, 10,000,000 from tanks, and 8,000,000 millions from "other sources."

These irrigating canals are not mere ditches. The main channels are as wide and deep as many of the big rivers. The Great Ganges Canal, with its distributing channels, is 9,900 miles long. It is responsible for the watering of 1,700,000 acres. The main canal is 200 feet wide and 10 feet deep, and it crosses four great torrents. It serves a tract of country 360 miles distant from its head works. Two rivers, 200 feet and 300 feet wide respectively, are carried over it in masonry aqueducts. The canal crosses the Solani Valley by an aqueduct and embankments 2¾ miles in length. At this spot 7,000 cubic feet of water passes each second, and the waterway is 170 feet broad and 12 feet deep.

A more recent enterprise of this description is the great Chenab Canal in the Punjab. It is fed by the waters of the Chenab River. It comprises some 2,800 miles of channels, spreading like the veins of a man's head over a tract of country little less than 4,650 square miles in extent.

The laying out of this scheme was a very arduous task. The survey parties had to work across vast stretches of totally uninhabited country, where the only source of water might be a brackish well 100 feet deep, and where no supplies of any kind could be obtained. It was often necessary to remain in the field throughout the hot season, when the temperature rose to over 110 deg. Fahr. in the shade.

In the digging of these channels—the main one as wide almost as the Hudson above New York—thousands of natives were employed. What they greatly feared were the man-eating tigers which prowled around the camps at night. Armed sentries had to be posted at each camp after dusk to drive these brutes away. As it was they succeeded in carrying off several workmen, causing much panic among the men. On this reclaimed land there are now hundreds of thriving villages, and a population of over a million souls. Two million acres of crops now grow annually on land which was once waste.

As already stated, some 10,000,000 acres of land are irrigated from tanks. These are not tanks in the sense which we attach to the term, but veritable lakes or reservoirs of vast extent. There are more than 30,000 of these tanks in the Madras Presidency alone. In Mysore there are 40,000 tanks—three or four to the square mile. These are a source of anxiety, because if a flood should burst one, others in the vicinity would be swept away. There is a dam in Mysore, 142 feet high across a valley near Marakanave, enclosing a basin of 2,075 square miles, containing if it were filled, which does not often occur, 30,000,000,000 cubic feet of water. Yet this is only a "tank" according to Indian reckoning.

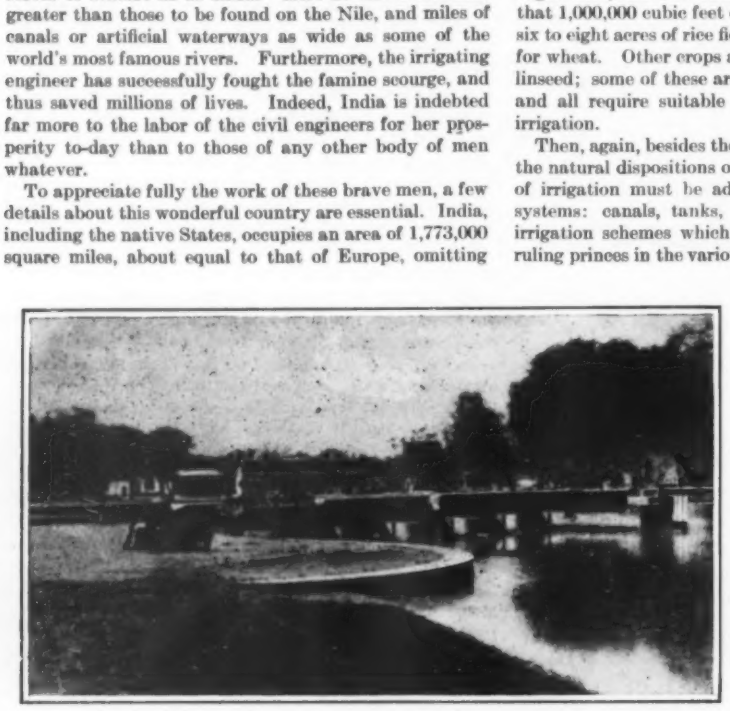
Then there is the Tansa Dam, also in Mysore, over 1½ miles long, and impounding 300,000,000 gallons of water. Other wonderful structures are the Nira Dam, 3,000 feet long, and the Khadakvasia Dam, at Poona, 1 mile in length. The erection of these dams, or tanks, deserve to rank among the engineering wonders of the world. That recently constructed across the Periyar River is a daring piece of work. It towers 178 feet above the bed of the stream, is nearly two miles in length, and impounds 13,300 million cubic feet of water to supply the Madura district, having an area of about 1,200 square miles.

"This dam," says the engineer responsible for its being, "had to be constructed in a river subject to violent and sudden floods, in an uninhabited tract of country, far from a village, very far from any railroad, in the middle of a range of hills covered with dense fores and tenanted with wild beasts; where there are no roads, or even paths, and where the commonest necessaries of life are unobtainable; where malaria of a malignant type prevails, and where the incessant rain for half a year was a constant deterrent to the importations of labor, and by its effect on the river rendered all work in the bed impossible for six months out of the twelve.

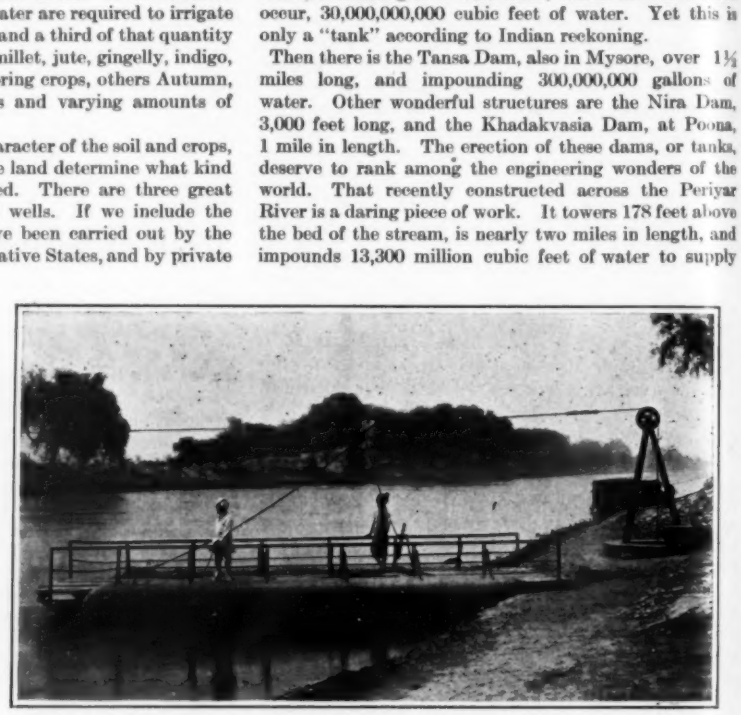
"The character of the environment may be gaged by the fact that for the first two years of construction watchmen, with drums and blazing fires, had to guard every camp at night against the curiosity of wild elephants, which constantly visited the works, uprooting milestones, dismembering new masonry, treading down embankments, playing with cement barrels, chewing bags of cement and blacksmiths' bellows, crumpling up zinc sheets, kneeling on iron buckets, and doing everything that mischief could suggest and power perform."

On one occasion an infuriated bull elephant dashed into a camp where 280 natives had retired for the night, trampling down the tents and scattering the workmen far and wide. Before the brute could be brought to bay and shot, he had killed two men. All that night search parties had to be sent out to bring in the scared natives, and it took all the persuasion of the engineers to induce the men to stick to their job and not to return to their homes.

Unfortunately for the irrigating engineer in India he has to be prepared to fight sudden floods caused by the melting snows upon the Himalayas. To carry off the flood water from the Periyar Dam, a tunnel 5,600 feet long was bored through a mountain ridge of solid rock. It is 12 feet wide by 7½ feet high. The area of the artificial lake formed by this mighty dam varies, of course,



Distributary head, upper Gugera branch Lower Chenat Canal.



Kerri ferry. Cable-propelled catamaran on one of the irrigation canals.

with the height of the water. It has a normal level and an escape level. One is 31 feet above the other. At the flood level the lake has an area of 7,454 acres, the greatest depth being 162 feet. The water is carried from the great reservoir through canals for a distance of 86 miles to the Madura district, where 180,000 acres of desert land have very recently been reclaimed.

A vast irrigation scheme is now in progress in the Punjab, about 40 miles south of Lahore, employing 8,000 natives of mixed nationalities, superintended by only four Europeans. When completed, it will irrigate about two million acres, and no doubt attract a large population to what is at present an uncultivated waste. The scheme involves the construction of three canals, one of which will be 200 feet wide, having a volume of water nearly ten times as great as that of the River Thames at Windsor. Yet this immense canal has to be carried across the Ravi River, which in flood time has a width varying between one and three miles, and a volume of water equal to half that of the Nile at Assouan. Another part of the scheme is a barrage across the River Ravi. This will be 1,650 feet long, having thirty-five gates, each weighing 18 tons, and measuring 40 feet in length by by 12½ feet in height.

Then in the Upper Swat Valley, on the northwest frontier of India, the engineers are piercing the Malakand Pass, with a tunnel to carry off the waters of the Swat River. It will be 11,266 feet long, 18 feet high, bored mostly through very tough granite. We get an idea of the difficulties of the task when it is stated that 400 drills have to be ground daily, so hard is the rock. The water brought through this tunnel will be impounded by a mighty dam, as large as those to be found in Egypt or even in the United States. How busy the irrigating engineer is in India to-day may be gaged when it is stated that besides the works mentioned, there are 1,326 miles of main State canals in course of construction, and 4,937 miles of distributing canals, nearly all in the Punjab region.

Experimental Study of the Mechanism of Writing*

Investigations in the New Science of Experimental Pedagogy

In recent years considerable advances have been made in the experimental study of the complex processes of reading and writing, mainly in the interests of a new experimental science, which is at present calling itself "experimental pedagogy," and at recent meetings of the British Association the Educational Science Section has devoted a good deal of attention to such work. In the Proceedings of the Royal Society of Edinburgh a further contribution to the experimental analysis of the writing process is made in a paper by Mr. James Drever, on the analytical study of the mechanism of writing.

Looked at from the outside, and regarded purely as a mechanical process, the writing act consists of certain movements and co-ordinations of movement of the fingers, hand, forearm and shoulder. Of these the hand movements and the work of the fingers are the most important. By employing various pieces of comparatively simple apparatus it is possible to separate hand and finger movements, as well as to isolate for observation and study both the pressure of the fingers in holding the writing instrument and also the pressure placed upon the writing point.

To Professor C. H. Judd, of Yale, we owe the original idea of a simple piece of apparatus which enables the experimenter to separate hand and finger movements. This apparatus consists essentially of an attachment for the fifth metacarpal, which carries a pencil or style for recording the movement of the hand. The original form of the apparatus was defective in several respects, but a modified form described in the above-mentioned paper seems to eliminate most of these defects. By comparing the record of the hand movement with the actual writing we can determine the part played by finger movement. It should be noted, however, that there is one movement of the hand in writing which cannot be recorded in this way. That is the movement known as pronation—the movement round the axis of the wrist.

Records taken with Judd's apparatus yield several interesting results. Some writers use little, if any, finger movements, and most writers, when writing at maximum speed, and especially with the pencil, approximate to this type. Ordinarily, however, in careful adult writing in this country, all the finer work in the formation of the letters is due to finger movement, and this to a greater extent in pen writing than in pencil writing. As a rule the writers themselves are quite unconscious of such finger movements. In the writing of the child, who is merely at the learning stage, there is little finger movement, but finger movements develop as facility is acquired.

The isolation of grip pressure in writing is secured by an apparatus consisting essentially of a double walled rubber capsule, inserted into the pen or pencil holder to take the grip (Fig. 1). The space between the walls, and also the inner space, are filled with mercury. A capillary glass tube passes into the inner space, and its top is connected by means of rubber tubing in the usual way with a recording tambour Any variations in pressure on the outer wall of the capsule are in this way transmitted to the tambour and graphically recorded by the marking lever on a smoked drum.

Very little work has hitherto been done in the study of grip pressure. The most striking feature in the grip pressure curve obtained is its rhythmical character (Fig. 3, VI). With the adult this rhythm is extremely regular, but it is absent in the earliest writing of children, first appearing about the age of eleven, and then with marked irregularities (Fig. 3, VII.). In writing with the pencil the grip pressure is considerably greater than in writing with the pen, and the difference between maxima and minima in the rhythm also greater. Finally, there are in adult writing definite indications that a word or even phrase is written with one total impulse.

Several different forms of apparatus have been employed for obtaining a record of point pressure in writing. Continental investigators have employed a writing plate, either connected directly with a lever for marking on a smoked surface, or resting on an air cushion pneumatically connected to a recording tambour. In Mr. Drever's apparatus the pen or pencil is attached to a receiving tambour, which forms the top of the pen or pencil holder (Fig. 2). This last

Fig. 1.

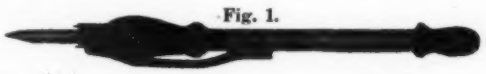


Fig. 2.

form of apparatus is exceedingly simple and convenient for use with children.

The study of the point pressure curve has already yielded some interesting results, which bear not only upon education but also on the study of mental defects. In normal adult writing two types of pressure curve were early and easily distinguished, and it is possible to distinguish three. The first, which is known as the masculine type, shows a single definite maximum of pressure for each word, and increased pressure with increased speed of writing (Fig. 3, IV.). The second, known as the feminine type, shows several maxima of pressure in each word, and diminished pressure with increased speed of writing. The third, which might be called the clerical or mechanical type, shows great uniformity of pressure in each word, and practically no change of pressure with increased speed of writing; further, there is comparatively little increase of speed beyond the ordinary rate, and in some cases the speed actually diminishes, while the subject thinks he is writing faster.

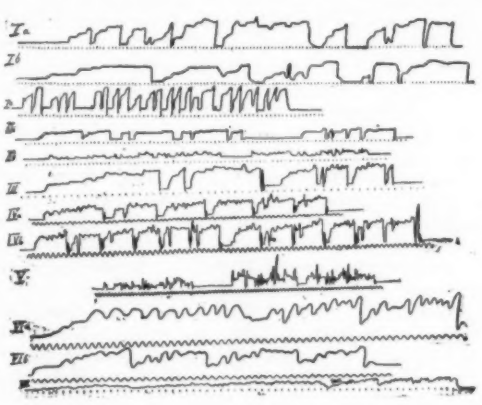


Fig. 3.

I to III. Point pressure tracings from children. Time record in seconds by Jacquet Chronograph. Ia. Child of six. Words "The cow gives us milk." Ib. Child of six (first attempt at script). Words "A man can." Ic. Child of six (printing). Words "A man can run." IIa. Pencil writing, and IIb. Pen writing of child of eight. Words "Moray House School," written twice in each case. III. Child of eleven. Pencil writing. Words "Moray House School," written twice. IV and V. Point pressure tracings from adults. Time record in ⅕ seconds by vibrating spring. IVa. Pencil writing, ordinary rate. Words "Moray House School," written twice. IVb. Pencil writing by same subject, maximum rate. Words "Moray House School," written four times. V. Pen writing, slow and fast. Words "Moray House School," written once slow and twice fast. VI and VII. Grip pressure tracings from adults and child of eleven. Time records for adults in ⅕ seconds and for child in seconds. VIa. Adult pencil writing. Words "Moray House School." VIb. Adult pen writing. Words "Moray House School Moray." VII. Child's pencil writing. Words "Moray House School" twice, slow and fast.

The pressure curves obtained from children differ from all the adult types. A flat-topped curve had been considered until recently the characteristic child's curve (Fig. 3, II.*a*). This curve does not, however, represent the first stage in the acquiring of writing The first curves obtained are more or less characteristically drawing curves (Fig. 3, I.). Such curves are best seen where the child begins with printed letters rather than script (Fig. 3, I.*c*). In this case each stroke requires a definite and separate impulse, and this is well marked in the pressure curve. In the earliest script the curve seems merely irregular, but this is due to variations in the drawing unit with which the child is dealing, which may be a single stroke, a letter, or a group of letters. The second stage in learning to write is marked by what was formerly called the child type of pressure curve, a curve with a strikingly regular, flat top, which is still a drawing curve, though the child is now drawing the whole word. This curve passes gradually into the curve with rippled top of adult writing, the time when the transition can really be said to take place being about the age of ten or eleven (Fig. 3, III.). The transition seems to mean two things. In the first place the necessary co-ordinations are established to such an extent that the mechanism of writing works without attention to the individual strokes and forms which the hand is making. In the second place, and partly because of this, writing has ceased to be drawing and has become language, the rhythmical variations in point pressure corresponding to the rhythmical variations in grip pressure, and being analagous to a certain extent to the rhythm of speech. When this stage is reached the impulse under the direction of which writing takes place is distinctly a word impulse, and sometimes even a phrase or sentence impulse.

It has also been found that the writing of defectives fails to show this characteristic rhythm of adult writing, while drugs like alcohol tend to impair the rhythm and ultimately to break it down altogether, apparently because of their effect on co-ordination. It is also somewhat interesting to find that the pressure curve is almost as characteristic of an individual as his signature, and persists even in left-hand writing without previous practice. There is evidently a wide field for investigation in this direction, and perhaps we may yet see the development of a real science of graphology based upon such investigation.

* From *Nature*.

Seasoning Cast Iron

In the manufacture of the higher types of machinery, care is taken to lessen the cooling stress of iron castings by annealing or some other means, in order to make the iron homogeneous and less liable to breakage or distortion. This process is known as "seasoning." It has been found in the case of ordinary test bars one inch square in section that there was a gain in strength of about 20 per cent due to the shocks sustained during an hour in a tumbling barrel as compared with companion bars from the same ladle, not so treated. This phenomenon has become recognized, and the American Society for the Testing of Materials has revised its specifications for iron castings prohibiting the tumbling of test bars prior to testing. In the case of castings that cannot be well annealed by heating, an effect of softening may be secured by tumbling them while cool, or otherwise subjecting them to shocks, thus accelerating the removal of internal stresses by molecular movement. It is interesting to note that castings improve with age, owing to the slow or gradual escape of cooling stresses due to rearrangement of the molecules.

Military Explosives—II

Their Chemistry, Preparation and Action

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2070, Page 151, September 4th, 1915

MODERN powders, though, have their disadvantages. Besides being more costly, they erode the interior of the arms more severely and wear them out faster, a fact easily understood when the greater force developed is remembered. The erosion rests largely on the combustion of the nitroglycerine which, as already mentioned, is characterized by a high temperature of explosion. On this account France and Russia have abandoned the use of nitroglycerine powders, and use pure nitrocellulose products. England seeks to modify the effects of overheating the metal of the arm by adding inert substances to the nitroglycerine. The superiority of nitroglycerine powders is a question not yet settled, although it is certain they produce better ballistic results, but do more damage to the weapons For this latter reason the Germans are also endeavoring to reduce the amount of nitroglycerine in a charge.

Another disadvantage of modern powders, which will probably disappear as their nature is better understood, lies in their deterioration during storage. Black gunpowder could be stored for years without giving it a thought; if it were not too hot or did not suffer from dampness it remained unchanged indefinitely. The tendency to decompose, even in a short time, exists in all the smokeless powders, and the products of decomposition give rise to the danger of spontaneous combustion. Such powders have to be constantly watched and tested at regular intervals. Besides, the explosives in them are stabilized by combination with certain other substances that neutralize the products of decomposition. Among such stabilizers particular mention should be made of diphenylamine and the derivatives of urea.

The demand made on the propulsive powders is that the force developed shall drive the shot, but different service is required of the explosives contained in bombs, shells, mines and torpedoes that are intended to detonate with as much violence as possible to increase destruction. The explosive force demanded in military operations is very different from that needed for civil labor, for in civil life explosives are used to lighten work, as to split off coal or stone.

When the explosive substances became known the military authorities at once adopted the use of those based on guncotton and nitroglycerine. To these was added in 1886 picric acid that has tremendous explosive force; this, however, was largely superseded when in 1901 the aromatic nitro-compounds were discovered.

Formerly guncotton was used as a filling for shells, but premature explosions that destroyed both guns and artillerymen put an end to this experiment. To-day guncotton is only used in a moist compressed condition containing 10 to 20 per cent of water in submarine weapons, mines and torpedoes. Its qualities make it very suitable for these purposes; it can be stored indefinitely in a moist state, is insensitive to blow and friction, ignites slowly, but detonates tremendously if fired by a primer consisting of a small cartridge made of dry guncotton ignited by fulminating mercury. These are essential conditions for disruptives used under water. They must be unaffected by water, as it is not possible to exclude moisture fully from mines and torpedoes; neither must they react to a blow or friction, for mines have often to be laid under fire and rough handling is unavoidable. If submarine explosives were easily ignited, then the danger of fire for ships, mines, and torpedoes, which is by no means small now, would be greatly increased. On this account ordinary gunpowder, dynamite, picric acid, and various other substances are useless for submarine purposes.

"In sea-mines," says Dr. Krumbhaar in discussing the subject further, "the charge of compressed, moist guncotton varies, according to the desired end, from 40 to 230 kilogrammes; in the newer torpedoes it is about 130 kilos. The guncotton is laid in pressed disks one after the other; in the center is placed a priming cartridge of dry cotton which passes through the others, and is detonated by the cap at the top.

"Of late years research has discovered substances more suitable than moist guncotton for charging mines and torpedoes. Owing to the necessity of preserving military secrets, but little is known of them. It will not be a mistake to believe these substances have superseded guncotton in mines and torpedoes, because they are insensitive to water, are not affected by blow or friction, burn with difficulty, and have great explosive force."

Military authorities also make use of nitroglycerine as a disruptive. In a fluid state nitroglycerine is of little practical value, being neither transportable nor of use as a charge. It is, therefore, mixed with one third its weight of infusorial earth, whereby a paste of the consistency of putty is formed. Infusorial earth is a light, loose powder consisting of the shells of diatoms, and is found in large quantitfes in the Lüneburg moorland in Germany. A slight burning process frees it from all organic substances and makes it an excellent absorbent for nitroglycerine, the product of the mixture being dynamite. After the paste is thoroughly combined it is squirted through nozzles into the form of cylinders called cartridges or sticks, and wrapped in parchment paper. A disadvantage of these cartridges is that in cold weather the mixture freezes at 12 deg. Cent., and, in consequence of the hardening of the nitroglycerine, becomes unusable. Thawing it after freezing is a dangerous process.

Blasting gelatine is also a solid, easily handled form obtained by soaking guncotton in nitroglycerine.

The aromatic nitro-compounds are produced by the action of nitric acid or certain compounds of organic chemistry, the phenol derivatives and the hydrocarbons. Treatment with nitric acid introduces nitro-groups into the molecule, which give it explosive force without injuring its stability.

The oldest of this group of explosives is picric acid. Picric acid is made from phenol or carbolic acid, a coal-tar product. Carbolic acid was formerly much used as a disinfectant. In order to convert phenol into the derivative of nitric acid it is first treated with sulphuric acid, which is afterward displaced by nitric acid. The reaction is first very violent, and cold water must be used as a cooler; the temperature, however, gradually sinks, and in the end the mixture has to be warmed to bring the process to completion. The product of the reaction, picric acid, is a yellowish, crystalline deposit, which has still to undergo various manipulations before it is pure. Chemically, picric acid is a trinitrophenol; it is a strong acid, attacks metals as all acids do, and combines them to form salts. The salts of picric acid, especially those of potassium and lead, are very sensitive to friction and shock, which makes them at times very dangerous. Picric acid, therefore, cannot be brought into contact with metal; as a filling for projectiles it is always packed in pasteboard cases, or the projectile itself is covered on the inside with varnish and paint. Picric acid is slightly soluble in water, the solution has a somewhat bitter taste and dyes silk a strong yellow. Being soluble in water it is not impervious to moisture and can only be used for explosives under water when perfectly sealed. The attempt has been made to reach this end by covering the explosive substance with paraffine. Picric acid can be stored indefinitely without danger of change. This gives it a decided advantage over the unstable guncotton and nitroglycerine compounds. It is not sensitive to heat, melts at 120 deg. Cent. and burns with a very smoky flame. Neither is it affected by blow or friction, so it can be worked in a pressed or melted state by rotary and cutting tools. It is brought to explosion by means of an initial shock and detonates with a high velocity, exhibiting great force. Picric acid is put to various uses: as an explosive as a shell-charge, and lately as a charge for bombs. For shells of small caliber the acid is packed by means of hydraulic presses, for larger ones by melting. Melted picric acid does not explode easily and is detonated by a small, compressed primer. To the picric acid used as filling for bombs and shells there are generally added various compounds to increase the effect, among which are the organic substances treated with nitric acid, the nitro-compounds, as melinite, lyddite, ecrasite, and other well-known substances.

It was the competition between guns and armor-plate that forced the increase of gun-caliber. Picric acid, though, ceased to be of use as a filling for shells when the caliber grew very large. At the moment of firing a pressure is exerted on the base of the shot that is transmitted to the explosive charge of the shot; the pressure increases with the increase of the diameter of the gun-tube. The enormous pressure exerted in the huge guns of the present day cause the picric acid to explode at once, so that the tube bursts. Consequently another explosive had to be found.

Trinitrocresol, which is closely related to picric acid, is said to be of no practical value, although safer and having great explosive force.

The nitric acid derivatives of the hydrocarbons proved to be in many respects superior to trinitrophenol and trinitrocresol. The manufacture of these derivatives was originally difficult, as the nitration required a high temperature and strongly concentrated acids, but these difficulties vanished when the chemical works began to turn out concentrated acids in large quantities at fair prices. The simplest of the hydrocarbons under consideration, benzine, has not yet been converted into trinitrobenzine, but the somewhat complicated hydrocarbon toluol has for more than ten years been converted into the explosive trinitrotoluol. This is done by successive nitrations with nitric acid of constantly increasing strength.

The crystalline deposit obtained is freed from adhering acid by a centrifugal and purified by recrystallization. Absolute purity is required to prevent decomposition. Trinitrotoluol is of much value as a military explosive, because owing to its chemical composition it is entirely neutral. It corrodes no metal and can be brought into contact with the casing of shot and bullet material without forming explosive metal salts. It is insoluble in water, and is thus excellent for submarine explosions and for charging mines and torpedoes; the explosive energy is not affected by moisture. Trinitrotoluol is much less sensitive to friction and shock than picric acid, and has proved a satisfactory filling for shells, even for guns of large caliber. It is not sensitive to the sudden pressure of firing, and is not exploded by the friction which arises at firing between certain parts of the charge and between the charge and the walls of the shell. The destructive work of the German 42-centimeter mortars would have been impossible without trinitrotoluol.

Trinitrotoluol has further military advantages. Explosive charges are introduced into artillery shells to increase the destructive effect, and these charges are brought to explosion by means of percussion or time-fuses. Up to the present shells and shrapnel have been distinct from each other. The shells contained in a strong steel casing a violent explosive which when detonated destroyed the casing. Shrapnel are shot having a comparatively thin casing within which a large number of lead bullets are imbedded in wax or paraffine. The ignition of a propulsive charge at the bottom drives out and scatters the bullets at a given moment. It is now possible to unite shell and shrapnel in one shot by imbedding the balls in trinitrotoluol instead of wax. Ingenious ignition devices permit the charge at the bottom of the chamber to explode, giving the effect of shrapnel, or the imbedding substance is detonated, causing the bursting effect of a shell.

As trinitrotoluol is less sensitive than picric acid, so its explosive effect is also smaller, but for practical purposes it is sufficient. More carbon residue is disengaged in decomposition, but not to a dangerous amount. Substances yielding oxygen are added to prevent disintegration, as nitrate of lead, which should consume the carbon. The Belgian macarite is a similar compound.

Trinitrotoluol, owing to its slight sensitiveness, requires a more forcible initial shock for ignition. This is met by a slight increase of fulminating mercury in the cap. The amount of fulminating mercury needed for ignition is very small; even for large charges only 2 grammes are used. A plastic form containing toluols that are less nitrated and some collodion-cotton can be easily pushed into hollow shot with a narrow opening; the plastic form is also used when for ballistic reasons a certain weight of charge is necessary.

The domain of the aromatic nitro-compounds, of which the most important representatives are trinitrophenol and trinitrotoluol, has greatly increased of late years, as the growing number of patents shows. Experiments have been made in the nitration of all kinds of organic substances, and in this way many new kinds of explosives have been discovered. Whether some of these have proved useful for military purposes is not known.

"The attention given by modern chemistry to explosives," says our author again, "has not prevented exhaustive research in the direction indicated by black gunpowder. The result of these investigations was the finding of explosive niter and similar substances. The German army has not made use of these, but the Austrian army and navy have adopted an explosive substance, ammonal, which is one of them. Ammonal is to a certain degree a combination of the old gunpowder and modern powders; it consists of an intimate mixture of ammonium nitrate, charcoal, trinitrotoluol, and aluminium. The ammonium nitrate takes the place of potassium nitrate, because it causes no smoke and leaves no residue. In this mixture the pow-

dered aluminium generates an intense heat, and thus increases the velocity of the blow of the explosive. The effect of the explosion is similar to that of picric acid. Ammonal is by no means waterproof, but, on the other hand, it is not at all sensitive to shock or friction. This was shown in two test firings made by the Austrian military authorities. Two shells, one charged with trinitrotoluol, the other with ammonal were fired at armor-plate. The first burst in striking the plate, the second not until one meter beyond the plate it had gone through. This makes plain the destructiveness of an explosive that is insensitive to friction."

Besides propulsive and disruptive substances, military needs require igniters that cause these substances to detonate easily and fully. At present ignition is brought about almost entirely by the detonation of fulminating mercury, the most important component of the propellant in the primer and of the disruptive in the detonating cap. The primer acts through the flame produced and lets loose gradually the energy stored in the propellant. The explosive cap produces a sudden, violent shock upon the explosive charge by the percussion of the mercury fulminate, and thus releases the force contained in the charge.

The basis of all igniting agents is fulminating mercury. Discovered in 1799, it showed in 1815 its tendency to explode upon a blow. In 1867 Nobel saw that this explosion could bring about the detonation of explosives. Fulminating mercury is obtained by the action of nitric acid and alcohol on mercury, and is precipitated on the bottom of the vessel as a grayish-yellow substance. It is thoroughly washed and carefully dried. It is exceedingly sensitive to sudden friction or blow, but is not affected by gradually increased pressure, so can be pressed. It is employed exclusively for purposes of ignition, but as it detonates with great rapidity it cannot be used as a propellant, and as it generates a relatively small volume of gas it cannot be taken as a disruptive.

Besides fulminating mercury there are a number of other substances, mainly organic compounds of the heavy metals, of like composition and properties. Among them is fulminating silver, which is so sensitive to pressure that it detonates violently even when touched gently under water by a rod. Of late the easily exploded lead azide has been used in the manufacture of primers and explosives caps. The sensitiveness of this acid is not lowered by 30 per cent of water. Organic igniters have been found of late that are free from the heavy metals.

The force of the propellant is set free by the primer that is exploded by the firing-pin. The primer is filled with a priming composition, the chief ingredient of which is fulminating mercury. It also contains sulphide of antimony, a combustible which increases the flame that appears, and powdered glass. The hard, sharp edges of the glass aid the effect of the firing-pin. Another essential ingredient of the priming mixture is a substance yielding oxygen, oxygen hastening combustion and making it more intense. A good container of oxygen is potassium chlorate, but its drawback is that it generates chlorine, which rusts the arms in the course of time. Consequently, of late potassium chlorate has been superseded by rustless ingredients for the primer, as nitrates, chromates and peroxides. The mixing of the ingredients of the primer or cap is a dangerous operation, as friction can easily cause ignition and explosion. If the mixture is made without accident of any kind, it is pressed in small quantities into the copper cap.

The disruptive is ignited by the explosive fuse. The filling of this fuse consists of fulminating mercury and 15 per cent of potassium chlorate, to which is added for the easier management a slightly gummy solution. The weight of the charge depends upon the sensitiveness of the disruptive and is based on experience. In most cases a small amount of a particularly light priming disruptive serves as transmitter of the detonation. Thus chemistry has produced substances in the modern propellants, disruptives, and igniters which meet all military demands.

Agriculture in Germany

And Significant Facts About Potash

By Our Berlin Correspondent

THE remarkable standing of German agriculture is due to the assistance of a highly developed science rather than to the excellence of the soil or the advantages of a privileged climate. In fact, Nature, in the Fatherland, has, in both respects, been rather sparing of her bounties. However, the country possesses one treasure of inestimable value, viz., its deposits of potassium salts which are not found in any appreciable amounts outside Germany, and on which the agriculture of the world is, to some degree, dependent.

The present state of temporary national isolation, following on a period of practically unlimited exchange, lends additional interest to the potassium salt problem, some aspects of which are discussed in the following:

The potash in plants serves to produce and convert carbohydrates—starch, sugar and cellulose—from the carbonic acid of the air (absorbed by the leaves), and from the water supplied by the roots. In the absence of potash, starch and sugar are only formed insufficiently, and the yield of cereals, potatoes, etc., remains far below the average.

A skilled eye recognizes at a glance whether a plant receives its proper potash supply. There is, primarily, a luxurious development of the leaves, so that superficial observers are inclined to deny the importance of potassium fertilizers. This, however, is, at a later stage, followed up by an absolute standstill in the development of the leaves and by premature withering. In the case of great deficiency in potash, the leaves and, soon afterward, the remainder of the plant, will die prematurely. In a test made at the Bernburg Experimental Station, the sugar contents of a beet root would decrease from 16 to 8 per cent. On the other hand, an adequate supply of potassium salts not only furthers the production of those materials for the sake of which most agricultural plants are cultivated, but increases the resistance of plants against animal and vegetable pests as well as against freezing.

The amount of potash required by different kinds of plants varies enormously. Some, e.g., barley and wheat, are contented with very small quantities, while others, e.g., rye, oats, potatoes, beets, many leguminous plants and tobacco, are very exacting in this respect. Again, there are many kinds which, though satisfied with small amounts, require their potash in a soluble form, etc.

All soils containing less than 2 per cent of potash, will benefit from fertilization with potassium salts. This applies, apart from sand, to all marshy soils. Sandy loam also, in most cases, requires a potash supply, in opposition to an opinion largely prevalent among agriculturists. Special fertilizing tests should be referred to in order to ascertain whether or not a given culture requires an addition of potash to its soil. Such tests, however, are readily made even by the smallest farmer.

The German potassium salt deposits were formed by gradual settling of a branch of the ocean which, once upon a time, covered a large portion of Northern Germany. When the saturation of the brine had reached a certain degree, the least soluble salts, viz., carbonate and sulphate of lime, would be the first to separate, while the sodium, potassium and magnesium salts still remained in solution, there being a continued, though not regular, water supply from the ocean. As, however, evaporation advanced, the main part of the rock salt separated, in its turn, thus becoming the mighty base of all present potash beds. The mother lye now contained, beside sodium compounds, only magnesium and potassium salts, which concentrated the more rapidly as the high temperatures and violent storms accelerated evaporation. Magnesium sulphate was the first to separate in what is known as the Kieserite region, above which the potash at last settled in a double salt of potassium and magnesium chlorides, mixed with some sodium chloride and kieserite. This double salt, known as carnallite, constitutes the main component of the more important potassium salt deposits and is found in inexhaustible amounts throughout Northern Germany.

The potassium salt deposits eventually became covered with an air and water-tight coating of fine clay, on which a thick layer of substantial sand and clay settled in course of time. Great variety was, however, produced in the composition and arrangement of the salt beds by water entering through any fissures. Apart from carnallite, there are some other potassium minerals of importance to the agriculturist, viz., hard salt, produced from carnallite by the action of water, washing away the magnesium chloride, sylvinite, another product of carnallite, freed also of its kieserite, and kainite, in connection with which only magnesium chloride has been washed out.

The carnallite, kainite, hard salt and sylvinite are blasted out of the deposits 1,000–3,000 feet in depth, by means of several explosives, after which they are taken to the surface in cages and ground to fine powders immediately suitable for use as fertilizers. From carnallite there are, however, made also by artificial processes—dissolving, crystallizing and drying—special fertilizers containing a high percentage of potash, of which a 40 per cent potassium salt is of growing importance for German agriculture.

The German potassium industry was, of course, deeply affected by the outbreak of the present war. Exports to the United States, which of late years, amounted to about $14,000,000, decreased immediately very considerably, because the German shipping companies had to discontinue their service, while neutral lines could not offer sufficient cargo space for the quantities of potassium salts which had been ordered. Moreover, the German Government issued a temporary export prohibition, which was not removed until the end of September. In fact, only 60,000 tons could be exported to the United States in the months from August to December, inclusive, while 578,000 tons had been shipped in the corresponding period of the previous year. This resulted in a serious shortage of potassium salts, and the prices of potassium chloride rose from $38 to $42 to $80 and even $120 per ton. Such prices, however, could only be paid by chemical works, and not by agricultural concerns. At the end of January last the export prohibition was renewed, thus bringing shipments to a standstill, so that fancy prices of up to $200 per ton were demanded. This state of affairs is the more inconvenient as potassium salts cannot be dispensed with for the cultivation of the most important crops of North America, viz., cotton, tobacco, sugar cane, maize, fruit and vegetables.

There are, at present, 193 potassium salt works in operation in Germany, while another 100 are being erected. These represent an invested capital of upward of $400,000,000 and are combined in what is known as the Potassium Syndicate (Kalisyndikat), Ltd., with headquarters in Berlin. In mining and in factories, the German potassium industry employs about 2,600 persons in various official positions, as well as 45,000 workmen. About 2,200 boilers produce the more than 350,000 horse-power required for a total of 2,700 engines. The average daily production, in normal times, amounts to 3,870 carloads each of 10 tons, and rises at times of brisk business, in spring and autumn, to 6,000 car-loads.

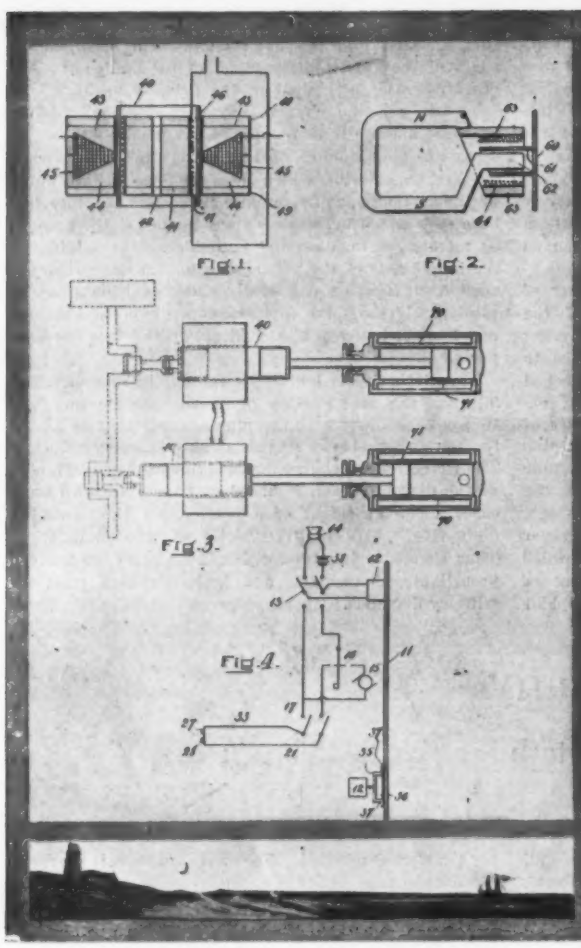
The Potassium Syndicate embraces the whole world in its business operations. It has everywhere abroad its own representatives, and in all important countries its own experts, whose task consists of instructing farmers in the proper way of using the salts. The potassium industry also embraces the world literally, insofar as the sacks required for last year's shipments, if placed in a row, would reach more than twice round the equator.

The following table shows the amount of potassium salts used per square kilometer of tillable land in Germany and the United States respectively, and strikingly illustrates the rapid advance in the course of the last few years:

	German Empire:	United States:
1890	68 pounds	12 pounds
1900	298 "	30 "
1913	1364 "	107 "

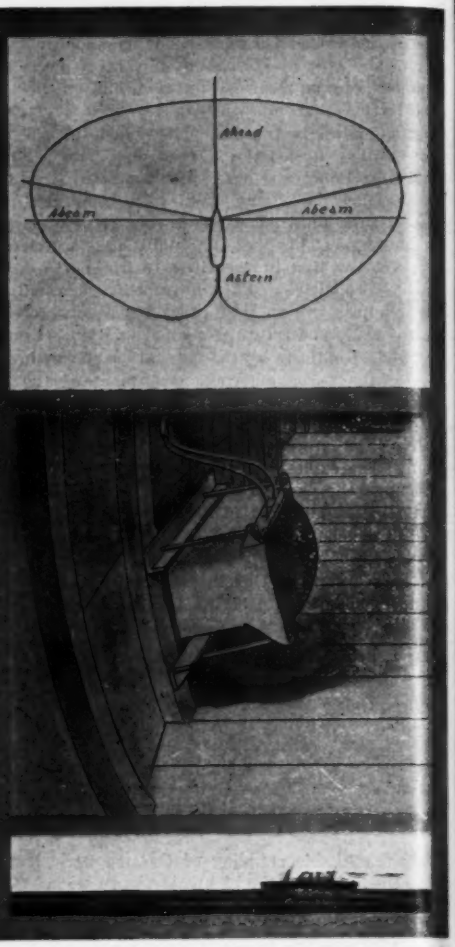
With the increased use of potassium in Germany, there was, of course, connected a corresponding increase in the average annual yields.

According to a bulletin of the American Railway Engineering Association, the Delaware, Lackawanna and Western Railway started to use screw spikes instead of cut spikes for holding the rail to the sleeper early in 1910, and during the past five seasons 5,120,000 flat-bottom tie plates and approximately 12,272,000 screw spikes have been placed in new and old tracks. The same company also commenced to use creosoted sleepers on an extensive scale in 1910. It was found, after some years' experience, that much damage was done to the sleepers by the use of flange tie plates, and it would seem that it was this that led to the adoption of the screw spike, as it held the road tight to gage and allowed for the use of a flat-bottomed tie plate. The latter are 7 by $10\frac{5}{8}$ by $\frac{3}{4}$ inches. The sleepers are adzed and bored by machine and two machines adz and bore 5,000 sleepers per day without difficulty. The cost per sleeper for adzing and boring, including interest, depreciation, operation, running repairs, electrical current for operation, does not exceed $1\frac{1}{2}$ cents per sleeper. From some other figures given in the Bulletin it appears that the cost of boring sleepers on the job is $3\frac{1}{2}$ cents each.



Various applications of the Fessenden electric oscillator.

Prof. Reginald Fessenden and his electric oscillator.



Tank attached to skin of ship for receiving submarine signals.

Submarine Signaling

Some Recent Discoveries for the Safeguarding of Ocean Navigation

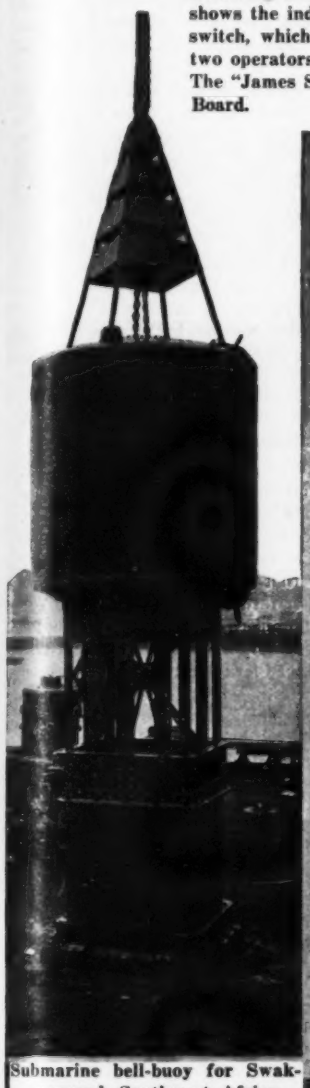
Of all the perils which attach to ocean navigation the most paralyzing are undoubtedly those caused by fog. No type of ship is immune from its terrors, and the larger and faster the vessel the greater the menace. Every ship captain is well aware that impending death and disaster lurk for him in fog, though his vessel be one which under ordinary, or even extraordinary conditions of wind and wave, is practically superior to all dangers. He is quite able to avoid rocks and shoals by the provisions which science has made available to him, and no storm at sea is able to shake his confidence in the staunchness of his ship; but fog takes away his eyes and filches from him the sure dependence on his ears which he has in a clear atmosphere. He can no longer be sure of either the direction or distance of origin of sounds he may pick up, and so must needs bow to a *force majeure* which he cannot control. When it is realized that these conditions are practically the normal conditions of service of underwater vessels, some idea may be formed of the difficulties of submarine navigation, for submarines are almost at as great a disadvantage as a surface ship in a fog. They dare scarcely show even a periscope when in the proximity of an enemy vessel, unless it be absolutely necessary to take that risk in order to deliver an attack. It is little wonder, then, that the question of submarine signaling is attracting much attention, for it promises to provide both mouth and ears to these vessels, in the sense that by its means a submarine and its mother vessel may be put into more or less perfect communication. Each may be able to originate and to receive signals by means of sound waves propagated in water instead of in air.

It is true that large submarines are provided with wireless telegraphy apparatus, which is of much use on the surface but of little or none when submerged. The speed of sound transmission in water is more than four times that in air, but the greatest advantage is that the direction of origin can be obtained with considerable accuracy, whereas the action of air upon these waves of sound, more especially air filled with fog, is mysteriously disconcerting. As long as thirty years ago, Professor Tyndall, on behalf of Trinity House, and Professor Henry, authorized by the United States Government, agreed, as the result of separate researches, that fog signals in air were quite untrustworthy, and to this day the authorities warn mariners against placing implicit trust upon air signals which, depend on hearing alone, without the corrobating evidence of vision.

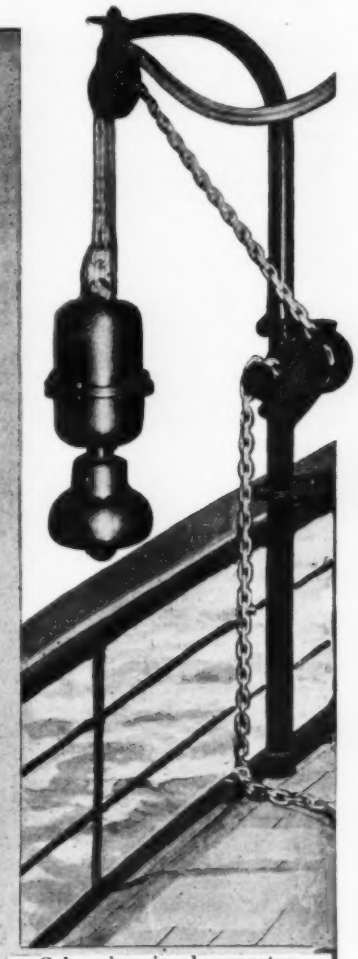
There is no novelty in the idea of producing sound waves in water. It is stated that Cingalese fishermen have handed down from remote times a method of submarine signaling by means of striking an earthen bowl submerged outside their fishing boats, their code signals being picked up on other boats by the simple expedient of placing the ear against the hull of the boat. Most people are familiar with the classic experiments made in 1826 by the two scientists Colladon and Sturm on Lake Geneva, in which these pioneers determined that the velocity of sound in water was 4,708 feet per second, and that they could pick up signals at a distance of 32 kiloms. Practical application of the discovery was long in coming, and it is only in recent years that its potentialities have been appreciated. More than fifty years elapsed before the first patent was taken out in this connection. Since then intermittent investigations have been made by Edmunds, Mundy, Gray, Edison and many others, and these have gone to build up the certainty that submarine signaling is not only a practical possibility, but also a most valuable aid to navigation. It was exploited at first mainly for the purpose of sending out warning signals from shore stations when lights were invisible and air-borne sounds unreliable, but that is obviously a restricted application of its usefulness, for it is confined to emission of signals from fixed points and reception of these signals by passing vessels in the immediate neighborhood.

The possibility of fitting ships with an installation comprising both transmitter and receiver opened a much wider field of operation, but coincidently a greater number of difficulties. It made possible the great advantage of underwater intercommunication between passing ships at any point in their voyages and under conditions of danger from fog. Development of even such a useful possession for commercial vessels is slow, but in war times its military value in widening the possibilities of service of submarines is a different matter. It is obvious that such a development would need no adventitious aids. The limitations of the submarine have been too clearly shown wherever their quarry has been a fast-moving warship to make it at all doubtful that something more is needed than the periscopes to aid the submerged vessel in locating her prey. It is no secret that many submarines are fitted with both submarine bells and receiving microphones which act well within a limited area, and with these communications of a kind, can be kept up with a mother ship at short range. More powerful ears are, however, required to detect at long range sounds which are propagated by a mother ship or by propellers or engines of an enemy so that her position and distance may be determined in darkness and without the necessity of coming to the surface in daylight. The original method of propagating sound waves was the submarine bell, while the receiver was a kind of large trumpet fitted with a rubber diaphragm. Developments of this method have resulted in the adoption of a peculiar form of thick rimmed bell to propagate waves of sound in association with an ordinary microphone as receiver. By immersing the microphone in a tank of water attached to the bow of the vessel below the water line quite successful results have been obtained. More than a hundred bells are in operation at transmitting shore stations and more than a thousand vessels are fitted with microphone receivers. The peculiar sounds emitted by these bells do not lend themselves to Morse signaling, nor is their range very great under sea conditions, where many other ship noises combine to muffle and confuse them. It was therefore a great advance when it was found that longitudinal vibrations of a wire or a ribbon of metal produced much more powerful waves of energy in water. Most of us can remember the boyish delight we found in producing such vibrations by means of a piece of string coated with rosin attached to a small tin, so that friction between the thumb and forefinger set up longitudinal vibrations which were more powerful than pleasant. Berger's apparatus, first tried in the Danube in 1910 with a piano wire 2 mm. in diameter, transmitted messages 2.8 kiloms. Further experiments with a wire of double the thickness increased the range to four miles. In each of these cases the wire was excited by friction of a hand-driven wheel, and it was found that a clear-toned note was produced, capable of being propagated in the dots and dashes of the Morse code. The principle being established, it was a simple matter to substitute mechanically controlled and power-driven exciters, acting upon larger metal ribbons. Such an installation with three ribbons, 1½ in. wide and $\frac{1}{8}$ in. in thickness, excited by a 3 horsepower motor, has been under test in the U. S. S. "Ar-

Receiving a Submarine Signal.—Chart room of the "James S. Whitney" of the Metropolitan Line, running between New York and Boston. This shows the indicator box, by means of which the officer can compare the bell sound on the starboard side with that on the port, by turning a switch, which disconnects one side and connects the other. There are two ear-pieces, so that an operator may have a receiver at each ear, or two operators can share the service, so as to correct their observations. The Fessenden oscillator will be connected to these indicator boxes. The "James S. Whitney" was one of the steamers used in submarine signal experiments conducted for members of the United States Lighthouse Board.



Submarine bell-buoy for Swakopmund, Southwest Africa.

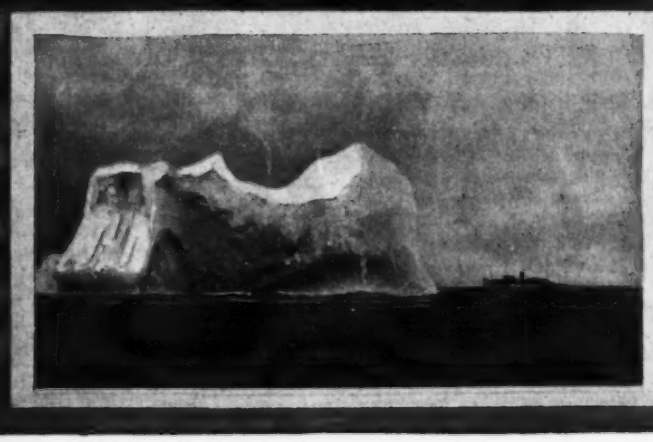


Submarine signal apparatus.

Outboard gear installed on a lightship. The bell hangs down 25 feet under water.

Submarine bell cable landing at Chebucto Head, Halifax.

On account of the severe storms at this point, a rail had to be used to hold the cable in position. There are now 148 bell stations in the world, and 1,225 war and mercantile vessels have apparatus for receiving the sound from these bells.



The United States revenue cutter "Miami" close to berg (off Grand Banks) similar to that which destroyed the "Titanic."

The Fessenden oscillator obtained echoes from icebergs two and a half miles away, distance being determined by stop-watch. Had the "Titanic" been equipped with an apparatus capable of ascertaining the presence and distance of the iceberg she might have been saved.

kansas." Messages have been received at 10 knots range, but better results are expected when various adjustments have been made, and obviously the system is capable of great extension. More recently still a further development has been made by using an electrical oscillator designed by Prof. R. A. Fessenden, which, by means of alternating currents acting on a powerful electro-magnet, causes a light copper tube to oscillate a thousand times per second, and to impart from a suitable diaphragm waves having a length of 9 feet and a clear note five hundred times per second. This apparatus was also tested on the U. S. S. "Arkansas, and had a range of 10 knots, but when the transmitter was hung outside the ship in open water the messages were clearly readable at a distance of 30 miles. This instrument has the further advantage that it may be operated either as a generator or a motor, so that it becomes either a transmitter or a receiver at will. By using a Morse key the speed of signaling is equal to that of ordinary aerial wireless telegraphy, and it has therefore been sometimes called "submarine wireless." The art of submarine signaling is a rapidly developing one, and while it must still be looked upon as immature, there can be no doubt that under pressure of war necessities it will receive earnest attention, and in all probability be improved and adapted not only for use on war vessels, but eventually for the purpose of increasing the safety of ordinary ocean travel in peace times. Two papers on this subject have been read recently before the Society of Naval Architects and Marine Engineers in New York, one of which, by Commander F. L. Sawyer, U. S. N., is devoted to the possibilities of submarine signaling as a method of obtaining safe navigation in fog. Simple and inexpensive apparatus has been designed by which ships may locate one another within a radius of five miles, and communicate their respective bearings, speeds, and distances apart, so avoiding much of the danger of collision; but there are difficulties still to be overcome.

The submarine bell as a propagator of sound waves has the advantage that when struck its pulsations are emitted in all directions, but, as already said, it is not suited for Morse signaling. Diaphragm systems are powerful and suited for shipwork, but are naturally directive in their transmission. Similarly, all receivers are at present directive; they should also be "all round" in their action to give satisfactory results, and even when this is accomplished some means will have to be devised to eliminate the sound shadows caused by portions of the hull and by propeller noises in the wake which interfere with the intensity of the propagated waves. These difficulties will all be overcome in time, and the system developed to full usefulness. In the meantime, most valuable work is being done with the bell and microphone in the limited sphere to which they are applicable. The powerful bells in use at shore stations are unsuitable for use on ships, which at present are only fitted with receivers and so cannot communicate with one another—with the exception of some submarines which have both bell and receiver—but when it becomes general to fit large ships with transmitters the dangers from collision and stranding will be much reduced.

Experiments with a sound wave oscillator have shown clearly that the presence of an iceberg may be detected at a considerable distance. Echoes have been picked up at a distance of more than two miles by this means when no echo could be obtained with a steam whistle at a distance of 150 yards. There is the further advantage that the time of travel of a sound wave in water is only one fourth of that in air, and every second counts on a fast ship in the neighborhood of ice.

It remains to be seen whether the system will realize all it promises, and there is every reason to suppose that its military possibilities alone will attract sufficient attention to demand immediate investigation on a larger scale.—*The Engineer.*

THE PRINCIPLES OF PROF. FESSENDEN'S OSCILLATOR

PROF. FESSENDEN'S oscillator serves to produce, utilize, transmit, or receive compressive waves, such as are employed in the transmission of submarine signals.

Fig. 1 is a sectional view of an electrodynamic oscillator built according to Prof. Fessenden's plans, and intended to act either as a motor or as a generator. Fig. 2 is a diagram of a telephone receiver in which the principle of the invention is embodied, but the field of which is produced by a permanent magnet. Fig. 3 is a diagram showing the mode of energizing the oscillating conductor by means of a gas engine. Fig. 4 is a diagram showing the invention applied to the transmission and the reception of submarine signals.

In Fig. 1 the oscillating conductor 40 is shown in the form of a copper cylinder, and 45 is the magnetizing coil of an electromagnet, having north and south poles, 43 and 44. The central core is indicated by 41. Figs. 46 and 47 indicate the two windings of the stationary coil, constituting one of the elements of the transformer (of which the oscillating cylinder 40 constitutes the other) and connected with an external circuit.

The magnetic flux passes from the pole 43, through the cylinder 40 to the upper half of the armature or core 41, thence from the lower half of the core to the pole 44, and by way of the external ring, back to the pole 43. That part of the cylinder 40 which extends beyond the two windings 46, 47, is vertically grooved or otherwise formed to attain high resistance. The coil 46, 47 is preferably wound on the core 41, although it might be placed within the poles 43, 44. The upper and lower windings of this coil run in opposite directions, so that the current induced in the cylinder 40 may be such that the force exercised on the upper and lower parts of the cylinder will be of the same sign. Hence, the cylinder 40 can always be cut into two halves, and the windings 46, 47, can be given the same sign; the two halves of the cylinder then moved in opposite signs, so that no unbalanced inertia effects will be produced.

The core 41 and the poles 43 and 44 are preferably grooved vertically, in order to avoid eddy currents. The plates 48 and 49 serve to hold the pole pieces of the electromagnet and the core together. The core 41 is provided with an opening 42.

When an alternating current having a frequency of 1,000, for example, is passed through the coil 46 and 47, the cylinder 40 acts as a short-circuited secondary, in which is induced the same number of ampere turns as in the coil. Because of the gap, which may have 15,000 lines per square centimeter, the current is raised and lowered with great force, the path being of any desired length. If the side of a ship or the rod of a locomotive piston were fixed to the extremities of the cylinder 40, they would be thrown into movement, possible only because of the powerful connection between the two elements of the transformer. The time constant is very small, because of the feeble self-induction of the oscillator, due to the mutual neutralizing action of the primary and the secondary.

In Fig. 2 another construction is shown, adapted for telephone use. The diaphragm of the telephone is indicated by 60; 61 is the cylinder or oscillating tube. *N. S.* is a permanent magnet, one of the poles of which constitutes the core 62, and the other pole 63 is of a circular form and incloses the stationary coil 64. In this case only a single gap is employed, since the magnetic lines pass between the pole or central core and the exterior concentric annular pole. When the currents coming from a microphone pass through the coil 64, the tube 61 vibrates, and the diaphragm 60 to which it is fixed reproduces the sound.

Fig. 3 is a diagram of the oscillator in the form of an alternating-current generator, two connected oscillators being energized by two pistons 71, acting in opposite directions in the cylinders 70, and each piston being connected with an oscillating cylinder 40. When a certain number of these units are employed, they can be connected in parallel, and the synchronization is such that neither a crankshaft nor a flywheel is necessary; control is effected simply by regulating the ignition. In adopting this novel construction an obstacle is overcome, which prevents the employment of oscillating dynamos, that is to say, the carrying along of the lines of force with the movement of the conductor. This is true to such a degree that the telephone receiver shown (Fig. 2), is much more sensitive to equal movements than any carbon microphone. The absence of this carrying along of magnetic lines and of inductance and hysteresis adapt it splendidly for syntonization. Such microphones can be connected in series or in parallel, which cannot be done with carbon microphones, because of the difference in phase.

Fig. 4 shows the application of the oscillator for submarine signaling. The apparatus is mounted directly on the plating 11 of a ship. If preferred, a diaphragm may be inserted in an opening made in the side of the ship, or the diaphragm may be fixed to the side of the ship, within the hold, the space between the diaphragm and the side of the ship being filled with water or with some other liquid, such as oil, which can be put under pressure. Instead of a liquid, a compressed gas can be employed, such as air or carbon dioxide. This diaphragm 35 is shown fixed to the inner side of the plating 11 of the ship; 36 is the fluid, and 37 a rubber guard ring. The diaphragm can be so constructed that, when it is touched, it will vibrate for some time. The apparatus 12, mounted on the plating of the ship, is similar to that shown in Fig. 1. When the switch 13 is thrown and the key 16 is depressed or moved to the right, the current from the alternator, or from the source of intermittent current 15, passes into the apparatus 12, and causes the cylinder 40 (Fig. 1), to vibrate powerfully. The cylinder being fixed to the plating 11 of the ship, directly or indirectly, as when it is mounted on the diaphragm 35, or secured to a rod or a spring, produces in the water, outside of the ship, compressive waves similar to acoustic waves in the air, which are transmitted and received at the receiving station. The waves thus transmitted may be of any desired frequency, from five to several thousand per second. In practice, the frequency is preferably determined by the frequency of the source 15. The key 16 may be employed for signaling, as in the case of ordinary telegraphy. When the switch 13 is raised, the apparatus 12 is placed in circuit with the battery 38 and the regulator 14, which may be a carbon telephone transmitter in which strong currents are used, or a transmitter and relay.

Telephonic communication through water is effected by speaking into the transmitter 14. When the switch 13 is lowered and the switch 17 is raised, and when the key 16 is raised (moved to the left), the apparatus 12 is connected with the receiving circuit. In this position, when the compressive waves, coming from some other station, are projected against the side 11 of the ship, they move the plating, carrying with them the cylinder 40, and the movement of this cylinder generates in the coils 46 and 47 (Fig. 1) currents which actuate the receivers 27 and 28. The current entering at the right side of the switch 17 and of the switch 21 passes through the receivers 27 and 28, which are in series, and returns through the conductor 33. Instead of switches, one may use the ordinary telephone circuit of land lines.

Great Inventions and the Public

Two excellent examples were recently given by Prof. R. A. Gregory, F.R.A.S., in the course of a paper on "Science in the Daily Press," read before the Circle of Scientific, Technical, and Commercial Journalists, of the manner in which the public likes to believe that men of science predicted from theory that this or that thing was impossible which was afterward achieved.

Wireless telegraphy and mechanical flight were quoted as examples of this tendency. In the former case it was the mathematical work of Clerk Maxwell and the scientific experiments of Hertz which produced wireless telegraphy, but to the popular mind the only man responsible for this wonderful discovery is Mr. Marconi.

Very soon after Hertz had described his remarkable researches on the production and detection of electromagnetic waves, the scientific world realized their importance. It was pointed out that as Hertzian waves possess the property of passing through fog or material obstacles, they could be used for a system of wireless telegraphy.

Mr. Marconi not only saw that the laboratory experiments of Hertz might be put to practical use, but also proceeded to adapt them to a system of telegraphy through the ether. To his knowledge, confidence and daring must be ascribed the commercial development of wireless telegraphy, but his achievements were direct consequences of the scientific work of Hertz, Maxwell, Faraday and Henry. As he himself acknowledged in 1900: "The experimental proof of Hertz, thirteen years ago, of the identity of light and electricity, and the knowledge of how to produce, and how to detect, these ether-waves, the existence of which had been so far unknown, made possible wireless telegraphy."

In the matter of mechanical flight the timely reminder was given by Prof. Gregory that, when Wilbur and Orville Wright commenced their experiments in artificial flight, the only exact experiments they could find as to the resistance of the air to machines driven at different velocities were those made by the man of science, S. P. Langley. They were the pioneers of sustained flight with aeroplanes, and they have acknowledged that their confidence in the practical solution of the problem was derived from Langley and his work. They said: "The knowledge that the head of the most prominent scientific institution of America believed in the possibility of human flight was one of the influences that led us to undertake the preliminary investigations that preceded our active work. He recommended to us the books which enabled us to form sane ideas at the outset. It was a helping hand at the critical time, and we shall always be grateful."

It is constantly stated that artificial flight would have been accomplished long before if engines light enough to drive them had been available, but that is not the case. Flights with two, three or more passengers show that lightness of the motor is not the only consideration, and motors with equivalent weights were available ten years before the Wrights designed their man-carrying aeroplanes. It was by following the scientific guidance of Langley, and using mechanical ingenuity to extend it, that they were able to give practical effect to the desire of man to rise above the clouds.—*The London Daily Telegraph.*

Detecting Impurities in Steel

STUDIES on the possibilities of analyzing steel by spectroscopic methods have shown that there are great possibilities. In experiments appreciable amounts of cobalt, vanadium and molybdenum were detected in samples of steel, said to be entirely free from these elements. In the examinations made of iron, no sample was found free from copper or magnesium; and in all irons, except electrolytic iron that had been fused, showed silicon, nickel, cobalt and chromium as well as silicon and copper.

Care of Exceptionally Bright Children*

Special Methods of Training Necessary for Exceptional Minds

By Maximilian P. E. Groszmann, Pd.D.

We may distinguish four classes or types of exceptionally bright children using this term as meaning children who are in advance of their fellows of same age, especially in school work. This success in school, however, is not altogether an index of real mental excellence. The very first group of children which we may consider does not necessarily represent brightness or brilliancy at all. It simply represents success, at least temporary success.

This group is composed of children endowed with a good memory, largely of a mechanical kind. In school work which consists mainly of recitations and the acquirement of book knowledge, they are apt to make rapid progress through the grades. They "learn" because they retain the lessons and can reproduce them, as a sponge returns the water it absorbed, when squeezed out. Certainly, there are good minds lucky enough also to be endowed with a good memory; and weak minds whose weakness is augmented by lack of memory. But it does not infrequently happen that very mediocre minds, yes, even distinctly feeble minds, will, through having a good memory, outshine their betters in school work, at least during the elementary period, before the higher reasoning faculties come into play. At that time they will be hopelessly left behind, much the worse for their "learning" which does not represent any live value to them, and the acquisition of which has prevented them from preparing themselves for life in their own lowly fashion. In their case, it is a matter of early diagnosis to direct them along really educative lines.

The other types involve real intellectual faculties of an unusual character.

There is, first, the child whose physical and mental growth is generally more rapid than that of an ordinary child. His pace is faster, his process of maturing accelerated. He travels in an automobile, when the others ride on horseback or travel on foot. He covers distances with lightning speed. As long as his physical health and strength keep pace with his mental advancement, there is nothing to fear. But he certainly needs to be given the opportunity to live and learn according to his quickened rate. He must not be held back to chafe under the restraint of his vitality and initiative, and must be given tasks commensurate to his strength and ability to cover ground. In a number of school systems, arrangements have already been made, or thought of, to accommodate these racers, through semi-actual promotions, or individual advance schemes, or special classes. Yet, there is no generally accepted system to meet their needs. And the warning must be given that at the first sign of tension between bodily and mental development, or in the emotional sphere, such as is likely to appear at the pubescent age, a new adjustment becomes imperative.

The last two groups of exceptionally bright children are those in whom I am personally most interested and which suffer the most from the lack of adjustment in the ordinary educational system, in home and school. They have been more particularly the objects of study in the association which I have the honor to represent, and, being truly "atypical" children according to our tentative classification, have come under my personal observation at "Herbart Hall," our laboratory school.

There is the type of child in whom one faculty is developing at the cost, it would seem, of all or most of the other faculties. They will be bright in certain directions and dull or ineffective in others. Distinct types can be differentiated: the motor type which is largely constructive along motor lines; the sensory type; the artistic type; the mathematical type; the linguistic type, etc. As long as there is otherwise good physical and mental health these types must merely be recognized as such. Of course, all of us have some tendency toward specialization along one or another activity; but we are now speaking of those who possess pronounced gifts of a specialized character. If they are forced to conform to general treatment and average class aims, they are in danger of becoming mentally and morally warped, and of developing dangerous traits, losing their balance and getting out of touch with normal life conditions. They need a training which takes the lead from their specialty and makes all other mental activities focus in it. Under the guidance of wise parents and teachers such children may become splendid social assets, helping the world through their special gifts.

I have not in mind, in speaking of the training of this class of children, that their specialty should lead to a narrow elective system of studies. Not at all; they need the broadening which is given through building upon a culture level which covers all the main elements of human endeavor and thought. What they need is an opportunity for their individual attitude toward the subjects of instruction to assert itself. "We must start with the pupil's own point of view, and from this lead him to a recognition of the proper relations and proportions of all branches of human knowledge with reference to his individual needs. But before a special subject can assume the dimensions of a world-view, the different studies and occupations must have been explored and partly assimilated to be at last organized under the common heading of the individual aspiration and viewpoint." (Cf. the author's "Career of the Child," p. 325.)

In other words, the special bent furnishes the point of vantage from which to enter the entire field of learning, thus counterbalancing the one-sided development as far as possible. But unless the child's main interest is taken as the starting point, he will become hopelessly averse to study and all-around culture, and degenerate into a drifter or a narrow-minded egotist, devoid of socially constructive ability. He may even become an absolute failure, a burden to himself and to others.

Here is the case of W. B., a boy of 16. A mechanical genius; has constructed several workable motor boats; erected telegraph line between his playhouse and his home. Also erected wireless station on his home grounds. Goes about with his pockets full of tools. Interested in machines of all kinds, but not for using them, but for studying their mechanism; not the moving pictures but the picture machine is what interests him; got a typewriter to learn on, and broke it up to study the machinery. Takes bicycles, watches, etc., apart continually. Not much interested in the usual boy's games; never much enthused over anything; calm and self-possessed; physically normal and healthy. But has been a failure all along in grammar school. No tutoring could get him into the high school. As parents did not want to try special training away from home, his case could only be diagnosed but not relieved.

Very different did another case develop: H. H., a boy of 13. A decidedly inquisitive and experimental type. Built fires in the cellar, not from viciousness, but because he wanted to see what would happen. Played innumerable pranks on his schoolmates and teachers who did not understand him, so that he was constantly in mischief and upset all discipline. When he came to Herbart Hall his inquisitive tendency was made use of through experimental study of all kinds. He stayed only a few months and left altogether rearticulated, mentally and emotionally. Since he has been standing at the head of his classes in select private schools.

The last and most difficult type is the one where these special endowments are coupled with a nervous temperament, or even a neuropathic or psychopathic tension. All kinds of disturbances in the sphere of the nervous system and of the psychic life may occur and mar the mental health and the vitality of the body.

Here we have the genius and the crank; the great leader of men—the prince of commerce, the poet and the philosopher; the musical prodigy and the artist of high degree, with his Bohemian contempt of conventionalities. Sentiment is apt to overpower the reasoning faculties in many, and hysterical characteristics are frequent. Or, there is cleverness of extreme acumen untempered by qualities of the heart. There is lack of poise which may cause distinct mental derangement. In this sense, genius is akin to insanity. The greatest criminals of history belonged to this class, whether they were international crooks, or sitting on thrones, or in counting houses. The moral tone is often unhealthy, self-control weakened, the ego exaggerated, and morbidly sensitive. In some, this over-efficiency in one direction is coupled with complete underdevelopment in all others: Here we have the idiot-savants.

Children of this type—and the type can be recognized and diagnosed in childhood—need very careful study on the part of the physician and psychologist as well as the educator, so that a balance of vitality may be established. In order to preserve the excellence without yielding to the weakness and defect in the emotional and moral makeup, a healthy environment must be established for them; the nervous system must be toned up; sane life-habits must be developed; companionship of the right kind must be provided so as to have the ego rub up against other egoes; and contrary to the method suggested for the previous group, the special bent of the individual must be curbed and controlled until it blends more easily with an expanded self of variegated interests. Not that the special interest must be combated and thwarted, but it must be supplemented, and the overstrain diverted until it is relieved.

Not all of these children can be saved for independent life; but even these can be saved from destruction. And by giving the vast majority of them the benefit of a scientific diagnosis and proper training in youth, the human race will gain an enormous amount of constructive elements of leadership such as would otherwise either go to waste or become powers of destruction.

The following is a case in point: W. B., a boy of 9, highly nervous and with a system full of malaria. His principal asset and excellency was a most marvelous imagination. He was very mischievous and irresponsible. Once playing Wild West, he became so realistic that one of his comrades escaped an actual hanging only by the intervention of a passerby. Most erratic in school and home, he, who had been almost given up in despair by his parents and his physician, had a year's training at Herbart Hall, where his diet, regimen, schooling, play, etc., were carefully arranged. He blossomed out into an amazing case of progress, constructive imagination and self-direction. He went back to his home and to ordinary schools, saved from mental and physical disintegration, making good in every way, as one of the brightest boys among his fellows.

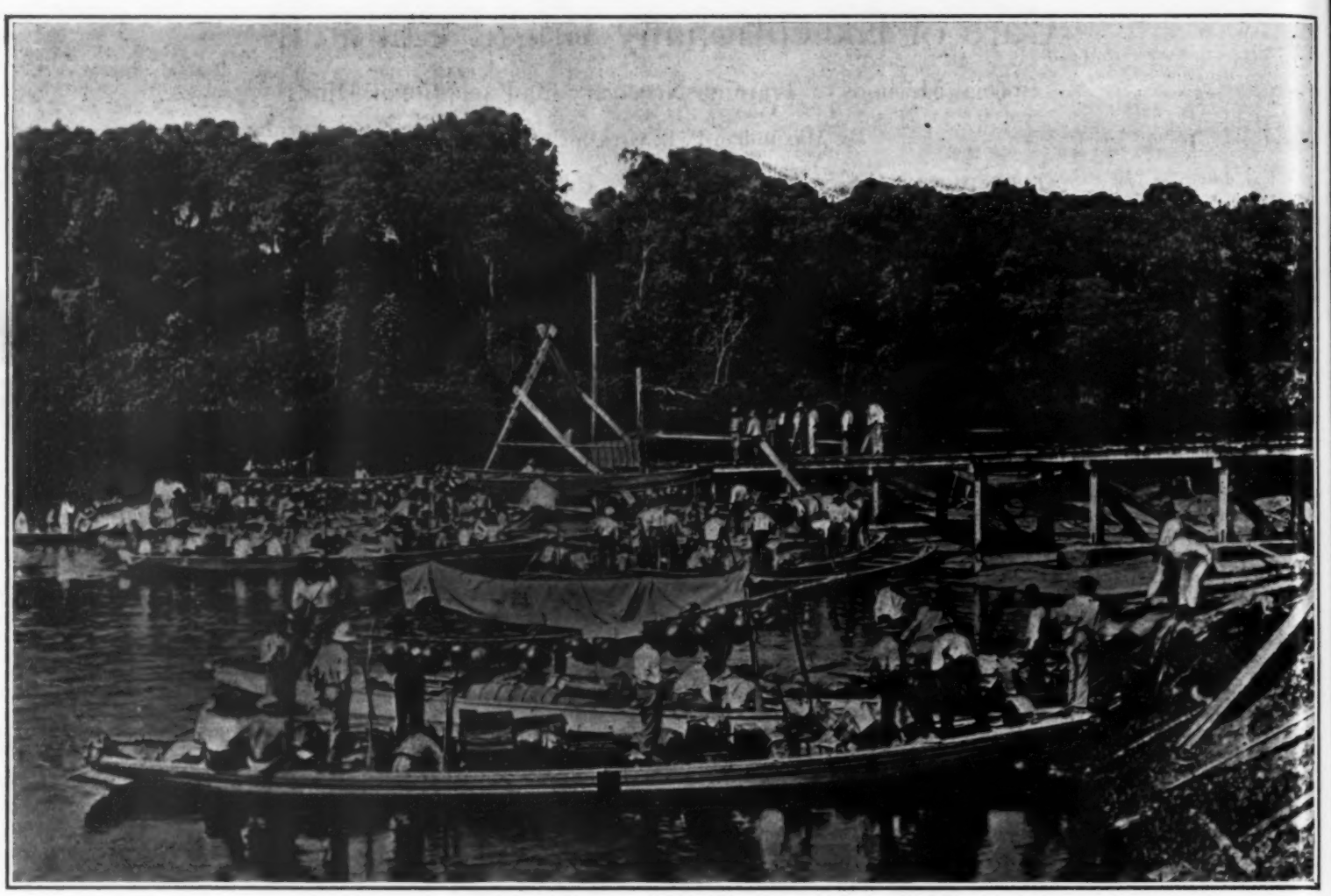
From the many other cases which I might cite, I will only mention the following, even though it was not my good fortune to help the child whose parents were so morbidly attached to him that they would not let him go away from them. W. K., a boy of 14, wrote a story when he was 9 years old, with excellent dialogue and plot; grammar excellent, wrote it himself on the typewriter. An inventive genius; thought out new appliances—patent applied for, for two of his inventions, one a slit fire-place for a boarding house, the other an organ player. Is a connoisseur of antiques with a vast knowledge of the history, value, marks, etc., of old clocks. May be seen at any opportunity in an antique store. Cannot play with other boys of his age; they are too silly for him. Likes cats with a passion. Screams if not allowed to play the orchestrion in railroad stations; has a passion for music. Sexually precocious to the degree that he knows the medical terms of sexual parts and relations. Has fits of melancholia, hysteria, passion, etc. Yet, on the other hand he is backward in a general way of school studies and self-adjustment to his environment. In a way, he is childish and utterly spoiled, without any real moral or emotional stamina. For him, a training such as indicated before, away from his home influences which are bad, would save him from mental disintegration which is now threatening him.

This brief statement of the case of the exceptionally bright child is obviously inadequate and incomplete. But I may have at least demonstrated the need of a careful consideration of the claim of these children to be educated in a manner which will be fair to them and helpful to the race. At present, they are receiving less attention than the feeble minded and defective. And yet, their number is at least equal to the number of the abnormals at the lowest end of the scale. And they are infinitely more worth while. For from them come our leaders and builders, our banner-bearers and thought heroes, our saviours and martyrs—as well as our destroyers and cranks and perverts and felons, the Mephistopheles and the Tartuffes. It is well that we have a regard for this great problem of clinical research and education.

* "Educational Foundations."

Stadium at Athens

A stadium for sports is constructed advantageously of reinforced concrete, and this material affords a quick building at a low cost. And a large structure with space for the various events and great seating capacity for spectators can be realized by our modern methods much more easily than by the older construction. As an example of the good use of reinforced concrete for this class of work we may cite the stadium at Athens, which serves as the scene of international sporting events. It is long and narrow and measures over 600 feet in length, and has seating capacity for over 50,000 persons, besides all the required accommodations.



Fleet of native boats laden with the products of the Balata tree.

The Balata Industry

How This Little Known Gum Is Collected and Marketed

BALATA is the milky sap of the bullet or balata tree (*Mimusops globosa*) of South America. It is often erroneously supposed to be identical with chicle, which is the coagulated latex of *Sapota achras*, or with caoutchouc and gutta percha. Balata is inferior in the extent of its uses to chicle and caoutchouc, but surpasses gutta percha and is now an important article of commerce. The first sample of this gum, as it is frequently called, was sent to England in 1859 for examination, but the reports received from manufacturers were not satisfactory. No further attempts were made to find a market for this product until 1862, when the second set of samples was submitted for consideration, and the merits of balata were then recognized and a demand created.

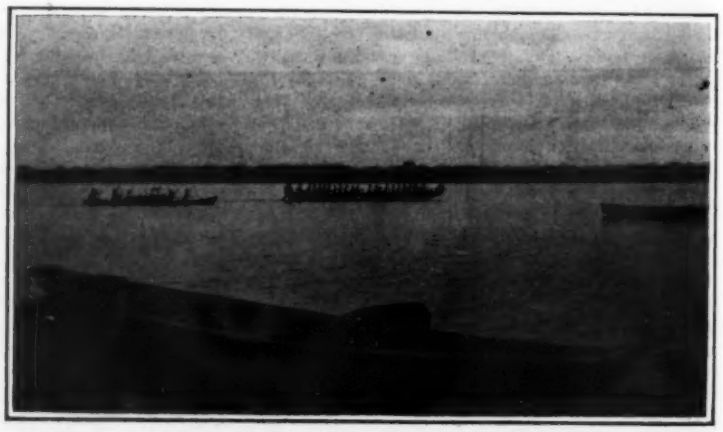
The balata tree is a member of the sapodilla family (*Sapotaceae*) to which the chicle tree belongs. Practically all trees of this group yield a gummy sap, which is collected and sold under the comprehensive name of gum. The true balata is readily recognized in the forest by its large size and its long smooth cylindrical trunk. It is found in Panama, Colombia, Venezuela, the Guianas and Brazil. Its best development is attained along the Orinoco, Essequiba, Demerara, Berbice and Amazon rivers. It is claimed by some that the balata reaches its maximum size in Berbice, British Guiana, where a number of trees yield logs 42 inches squared free from sap. On an average the mature trees range from 100 to 125 feet in height and from 5 to 7 feet in diameter. They are frequently without branches for nearly one half their total height.

The balata is gathered in a manner similar to that of chicle. The first thing the operator does is to hire men, consisting chiefly of negroes and Indians. He then advances them money with which they can obtain provisions and necessary implements. The clothes are usually very light and the tools they carry are a cutlass, calabashes, gourds and empty kerosine cans. They proceed into the balata bush and locate a camp or central depot on a favorable site. Rough, leaf-covered huts are put up and stakes firmly fixed from which hammocks are slung. A dabree, which is a shallow tray in which the balata latex is coagulated, is then built. With these preliminaries completed, the balata bleeders proceed to tap the trees, which is done by means of a cutlass, incisions being made not more than 1½ inches wide, about 10 inches apart, in a feather stitch pattern up the trunks of the trees, often to the height of the principal branches.

The latex is collected by placing a calabash at the base of the cuts. Wet clay or earth is placed between the calabash and the trunk to make a connection so the sap will flow into the calabash, the latex running zigzag from cut to cut down into the calabash. It is collected from these calabashes and taken to camp, where it is poured on the dabree, or drying boards, until it is coagulated. These dabrees usually hold from 5 to 30 gallons of latex. As soon as the latex is coagulated in these trays it is removed in the form of thin sheets and hung up in roughly-constructed drying sheds until they are dry enough to be transported to town.

Like all forest gums balata is very dependent, not only on the quality of the soil in which the tree grows,

Roughly constructed drying sheds for use in hanging balata.



Boats employed in carrying and towing balata.

but also on weather conditions. Too much rain is detrimental, and too much sunshine retards its flow; but an equally proportioned alternation of rain and sunshine tends to produce the maximum of yield. Trees yield about one gallon of latex each, which is equal to about 5 pounds of dry balata. There are trees which are said to have yielded 5 gallons of latex or 25 pounds of balata.

Balata resembles gutta percha so closely in its general properties that much of it is shipped from the Guianas and sold yearly for gutta percha; it has, however, many points of superiority. It is tasteless, gives an agreeable odor on being warmed, may be cut like gutta percha, is tough, leathery, remarkably flexible, and far more elastic than gutta percha. It becomes soft and may be joined piece to piece at about 120 deg. Fahr., but requires 270 deg. Fahr. before melting. Balata is completely soluble in benzole and carbon disulphide in the cold. Turpentine dissolves it with the application of heat, while it is partly soluble in anhydrous alcohol and ether. It becomes strongly electrified by friction, and is a better insulator of heat and electricity than gutta percha. It is applicable for all purposes to which gutta percha has been used. A few of these uses are for shoe soles and heels, cord, tubing, buckets, bed pans, basins, ewers, carboys, syphons, funnels, acid scoops and pourers, bowls, life preservers, etc. The material combines readily with colors, and being very durable is used extensively in making artificial flowers. Pure balata never becomes brittle.

The balata industry has made rapid progress during the last twenty years. The exports from all balata districts are increasing annually, and its value is also advancing. Over 1,000,000 pounds are annually exported from British Guiana alone, at a value between three and four cents per pound. The bulk of balata gathered during recent years has gone chiefly to England, but an increasing demand in this country has arisen. According to data derived from the Bureau of Statistics of the Department of Commerce, approximately 1,000,000 pounds of balata are imported annually into the United States. Our supply is obtained chiefly from Dutch Guiana and Venezuela, though a considerable amount comes also from British Guiana, Barbados, Jamaica and Trinidad.

Electrostatic Ore Separation*

Principles of a New Method of Metallurgical Treatment

By I. C. Clark

THE basic principles of electrostatic ore separation are those of static electricity. When two electrical conductors of like polarities are made to approach each other, they are mutually repelled; conversely, conductors of opposite polarities will attract each other. The force of this repulsion or attraction depends upon the conductive power of the bodies and the strength of the current with which they are charged. The conductors always remain separated by a non-conducting medium called the dielectric. Examples of such a non-conducting medium are air, mica, glass and rubber. The dielectric constant of air is assumed to be unity and the constants of other dielectrics are obtained by comparison with it. The principles of electrostatic ore separation are entirely distinct from those of electromagnetic ore separation. These two processes must not be confused, for in reality they are totally different.

CONDUCTIVITY OF MINERALS.

Every mineral will conduct electricity through its body or over its surface if subjected to an electric current of sufficient voltage. A great difference exists, however, between the relative conductive powers of various minerals. Many metallic sulphides and some other minerals are comparatively good conductors. Most gangue-forming minerals and a few metallic sulphides are poor conductors. The following substances fall into one or the other of these classes, the good conductors being native metals, pyrite, chalcopyrite, chalocite, pyrrhotite, galena, argentite, tetrahedrite, pyrargyrite, molybdenum, tellurides, garnet, magnetite, hematite, hornblende, biotite, graphite, black sands, most sulphides, and most copper, iron, silver and manganese minerals, while the poor conductors comprise quartz, quartzite, sandstone, granite, porphyry, feldspar, epidote, garnet, calamine, spinel, slate, fluorspar, monazite, calcite, limestone, dolomite, siderite, sphalerite, smithsonite, barite, gypsum, most siliceous minerals, most carbonates and most sulphates.

If a mixture of minerals containing good and poor conductors in a neutral state be allowed to fall upon a conductive surface charged to a high potential, the good conductors will immediately become charged with like polarity and be repelled with more or less force. The poor conductors, however, will require considerable time to become similarly charged. They may either fall from the conductive surface by their own weight or be repelled with only a slight force. Let this same mixture of minerals be charged with electricity opposite in polarity to that of the conductive surface and the operation repeated. The good conductors will immediately reverse their charge of electricity upon contact with the surface and be repelled as before. On the other hand, the poor conductors will be strongly attracted to the conductive surface, being charged with electricity of the opposite kind. Some time is required for the poor conductors to lose their initial charge and receive a charge similar to that of the conductive surface. Even then these minerals would either be repelled with only a slight force or merely fall from the surface by gravity.

Similar minerals from different places often possess different units of electrical conductivity. Sphalerite or blende is generally classed as a poor conductor. Occasionally this mineral will contain appreciable quantities of iron or manganese chemically combined with it. These impurities may alter the conductive power of the mineral in a marked degree. Instead of remaining a poor conductor, it may become a fairly good conductor, depending upon the relative amounts of combined impurities. Theoretically, an electrostatic separation may be made between minerals having only a slight difference in conductive powers. Practically the process is a very delicate operation. In order to insure a clean separation the minerals treated must have a marked difference in conductive power. Much trouble has been experienced in separating minerals where combined impurities alter their conductance. Careful watching is required when such minerals are treated in electrostatic separators.

Some minerals may be changed from poor to good conductors by electrochemical action. This is the practice at Ouray, Col., to a limited extent. Zinc sulphide, sphalerite, is immersed in a solution of copper sulphate, its surface becoming coated with a film of copper sulphide. After being dried this mineral is treated as a good conductor. Heat is also used to alter the conductive properties of minerals. Carbonates of poor conductivity may be changed to oxides of good conductivity in this way.

THE HUFF SEPARATOR.

The Huff separator is used almost universally in electrostatic separation plants. The principles of operation of this machine are illustrated in Fig. 1. The framework is made almost entirely of iron and is rounded to prevent shocks to the operators by contact with it. This grounding of the framework also assists in the separation by increasing the difference in potential between the charged and neutral electrodes, which

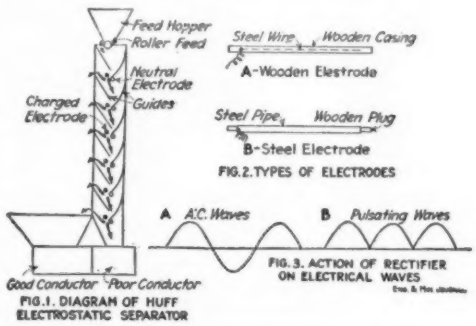


FIG. 1. DIAGRAM OF HUFF ELECTROSTATIC SEPARATOR

FIG. 2. TYPES OF ELECTRODES

FIG. 3. ACTION OF RECTIFIER ON ELECTRICAL WAVES

will be explained later. The charged electrodes to the left in the diagram are maintained at a potential of 20,000 volts and are carefully insulated from the iron framework. The neutral electrodes, to the right in the diagram, readily form a portion of that series of guides which are grounded with the framework of the machine. A dielectric of air separates these two series of electrodes, forming an exceedingly strong electrostatic field between them. All lines of force emanating from the electrodes are confined to this comparatively limited field. The ore in a neutral state is fed continuously on the machine by a revolving roller beneath the feed hopper. The feed is regulated by an adjustable feed gate and by the speed of the roller. After passing over the roller the minerals fall on a series of metal guides which direct them between the electrodes. While thus falling between the electrodes the minerals are subjected to the intense action of the electrostatic field. The good conductors are immediately charged with electricity similar to that of the electrodes and are repelled to the left as indicated in the diagram. The poor conductors require a much longer time to absorb this charge of electricity and fall through the machine by gravity before any appreciable repulsion takes place.

On some varieties of ore minerals three or more products may be obtained by making more than one split. In such a case the best conductor would be repelled farthest to the left and be collected in a hopper suitably placed. The poorest conductor would fall directly through the machine and be collected below, as indicated in the diagram. Minerals of intermediate conductivity would be collected in hoppers placed at intervals between these two. This triple operation is not often feasible, for in most cases a clean separation can be made between only two products. The majority of static mills now in operation make but one or two shipping products.

ELECTRODES, TWO TYPES BEING USED.

The electrodes on all of the Huff machines are adjustable, thus permitting a wide variation in the strength of the electrostatic field. In order to accomplish uniform mechanical work, the upper electrodes are placed far apart and the lower electrodes are held quite close together. The upper electrodes having first "pull" at the mineral particles will repel the good conductors with the greatest force. Consequently they are placed at a considerable distance apart, this distance being determined by experiment for every class of ore treated. The lower electrodes have the hardest work to perform, cleaning the poor conductors from last traces of good conductors. They accomplish this work by being placed closer together. The adjustment of electrodes can be determined only by careful experiment and will vary with each class of ore treated.

Two general types of electrodes are in common use in electrostatic mills, as illustrated in Fig. 2. The first type is made of wood, coated with shellac and inclosing a steel wire. This wire is directly connected to the electrifying apparatus. The second type consists of a hollow steel-rod, insulated from the framework of the machine by wooden plugs or supports, and connected to the electrifying apparatus. The wooden electrode was the type first used, though at present the metal electrodes are largely replacing them. The wooden casing is generally covered with a coating of shellac. After remaining in use for some time these electrodes become heated, due to the intense electrical action and the warm feed. The shellac coating becomes somewhat sticky and the falling mineral particles will adhere to it. This adhering mass may become large enough to form a short-circuit between the charged electrode and the grounded framework. In this case all the current generated would be immediately grounded and the minerals would fall directly through the machine, no separation taking place. Adhering mineral particles might still do damage without causing a direct short-circuit. All lines of electrical force will concentrate at the points of least resistance between the electrodes. A mass of adhering mineral particles will decrease the resistance of the dielectric between the electrodes at that point. The concentration of electrical action at this point will cause sparking and may eventually burn out the electrode. Dust is liable to collect at the ends of the hollow-steel electrodes. This layer of dust may bridge over the wooden insulating plugs, thus grounding the charged electrode through the iron framework of the machine. Drops of oil or grease are apt to fall on either type of electrode. Dust and mineral particles will collect at such places with the above deleterious effects. All electrodes must be kept free from grease and dirt, and constant attention is necessary to insure this. This is one of the most important features of the process and carelessness here may lead to serious results. A single charged electrode on one machine becoming grounded will ground all the remaining electrodes in the mill. In case the electrodes become grounded, the feed to all machines should be immediately shut off until the trouble can be remedied. An ample supply of new electrodes should always be kept conveniently at hand.

It is common practice in electrostatic mills to ground the neutral electrodes. This aids the separation by insuring the maximum difference in potential between the charged and neutral electrodes. The earth is always assumed to be at zero potential and everything connected with it will have a like potential. If not

* *Engineering and Mining Journal.*

grounded the neutral electrodes might accidentally be maintained at a considerable potential above that of the earth. This would decrease the difference in potential between them and the charged electrodes, thus materially hindering the separation.

HOW MOISTURE INTERFERES WITH SEPARATION.

In order to obtain a good separation all machines must be fed with warm, dry ore. The feed, necessarily crushed to a comparatively small size, would cause endless trouble by mechanically clogging the machines, if much moisture were contained. Dampness would also cause the mineral particles to stick together, thus resisting the separating action of the electrostatic field. A moist feed would render the electrical features of the process absolutely useless. The electrodes would be grounded almost immediately, the electricity generated being wasted before any work is accomplished by it. Even a small percentage of moisture in the feed hinders the separation materially. Water is a good conductor of electricity. A poorly conductive mineral might readily be changed to a good conductor by a film of moisture adhering to its surface. This increase in conductivity might be sufficient to cause the supposed poor conductors to be repelled with the good conductors, the value of the products formed being materially decreased. The dielectric of air between the electrodes should also be free from moisture, as damp air is a partial conductor of electricity. If this dielectric consisted of damp air sparking might ensue, current be wasted, and the lines of electrical force weakened. The electrical equipment of an electrostatic plant in itself may be independent of atmospheric conditions, but the process as a whole is not. The more moisture contained in the atmosphere the hotter must the drier be fired in order to insure a warm, dry feed to all machines. This will prevent water from condensing on the mineral particles or on the machines and dry the dielectric of the electrostatic field. The drier should be maintained at a temperature between 300 deg. and 600 deg. Fahr., depending upon atmospheric conditions and the character of the minerals treated.

TREATMENT OF DUST.

Large quantities of dust are formed during electrostatic separation, which is readily understood from the nature of the process. This is particularly true when a considerable percentage of the minerals treated is finer than 200 mesh. When falling between the electrodes the finer particles have an excellent opportunity to float off into the air. This dust, if not confined, represents a loss of mineral and impairs the health of the machine operators. At best the machine room of an electrostatic mill is an extremely dusty place in which to work. The operators generally wear respirators.

In order to reduce the bad effects from large quantities of dust formed, ventilators are placed over each machine. These ventilators are connected with a baghouse, suction being provided by an electric fan. A large percentage of the total dust formed may be recovered in this manner. A baghouse equipped with a dozen 30-foot bags, 12 inches in diameter, is large enough to handle all the dust from a fair-sized mill. These bags must be shaken and emptied every few weeks. A suction fan is usually necessary in the flue, in order to maintain a good draft through the drier. Large quantities of dust are given off here and a chamber for collecting it should be built below this fan. This dust chamber should be cleared once a month or oftener, as required. Without the installation of a system of dust collection, mineral losses from this source may reach a surprising figure during a month's run. Sanitary considerations alone will require the installation of such a system sooner or later.

All minerals require some sizing before becoming amenable to electrostatic separation. The extent to which close sizing is required depends entirely upon the character of the ore treated and can only be determined by extensive tests upon it. Many combinations of sizing should be tried until the one giving maximum recoveries is plainly evident. A coarsely mineralized ore requires less initial crushing than a finely crystallized variety. Some ores require no sizing below 12 or 16 mesh, while others demand close sizing down to 150 mesh. As a rule, from four to six distinct sizes are necessary to insure a clean separation. The following examples give the average sizing required for different grades of material:

1. Through 4 on 8 mesh. Through 20 on 50 mesh. Through 8 on 20 mesh. Through 50 on 100 mesh. Through 100 mesh.
2. Through 20 on 40 mesh. Through 60 on 80 mesh. Through 40 on 60 mesh. Through 80 on 100 mesh. Through 100 mesh.
3. Through 40 on 60 mesh. Through 80 on 100 mesh. Through 60 on 80 mesh. Through 100 on 150 mesh. Through 150 mesh.

No. 1 is coarsely crystalline, No. 2 of medium texture, and No. 3 finely granular.

Sizing is often accomplished by means of inclined "toboggan" screens. After being discharged from the drier the ore is immediately elevated to a series of these screens. Motion is imparted to the screens by revolving hammers striking against projections on them and opposed by springs, or revolving cams at the sides of the screens, also opposed by springs. Ample screening surface should be provided to make a sharp division between sizes. These screens discharge the ore into chutes or conveyors leading to the machines treating their respective sizes.

The necessity for sizing is apparent. In the separation of a good from a poor conductor, the good conductor is repelled with considerable force. If much difference exists between the various sizes of mineral particles, a large particle of the good conductor might mechanically carry off one or more smaller particles of the poor conductor. If, however, the particles are all of approximately the same size mechanical entrainment is less apt to happen.

The electrical equipment required for the operation of a static mill is comparatively simple. It consists in the main of an alternating-current generator driven by a small motor, a resistance box and a rectifier. The generator produces an alternating current of high potential but of low amperage. From the generator the current passes through the rectifier, which changes the negative alternating-current waves to positive pulsating waves, as indicated in Fig. 3. This pulsating current is necessary so that the electrodes will receive only a positive charge of electricity. If charged with ordinary alternating current the mineral particles would be successively attracted and repelled, thus causing a poor

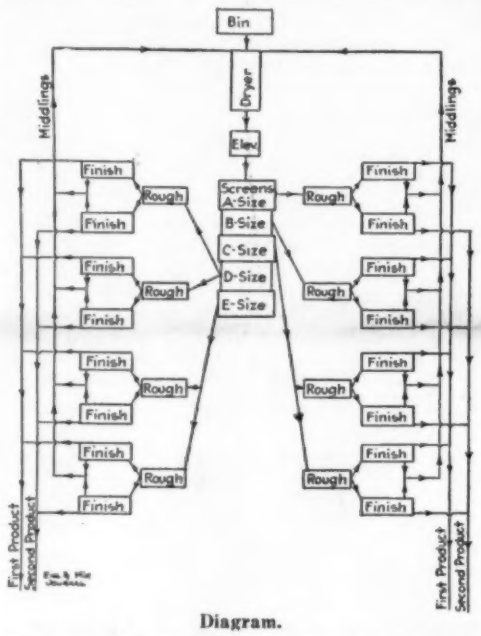


Diagram.

separation. The speed of the generator is regulated by a resistance box, so that the terminal voltage may be varied at will. The electrical equipment of a static mill is itself independent of atmospheric conditions, although the process as a whole is not.

Every electrostatic mill shows some variation in its flowsheet. In all cases, however, the ore passes through a drier, is elevated to the screens, where two or more sizes are made, and then passes over the different machines. In some instances one pass over the machine may be sufficient to form finished products for each size. Generally, however, it is necessary to re-treat each product from the roughing machine on a finishing machine, thus forming two or more finished products and a certain amount of middlings. One rougher and two finishers are now built in combination, performing the work of the three smaller machines, but requiring less space. The middlings from the finishers may either be returned again through the entire mill or simply be reheated and treated on small middling machines. The diagram shows a typical flowsheet in a somewhat simplified form. We will assume the proportion of sizes given in the accompanying table:

Size.	Through Mesh.	On Mesh.	Percentage of Feed.	Machines—Rougher.	Machines—Finisher.
A	20	40	10	1	2
B	40	60	15	1	2
C	60	80	20	2	4
D	80	100	25	2	4
E	100	..	30	2	4

This flowsheet has been simplified so that the general features of the mill are not disguised. All middling products formed are returned to the drier and pass through the entire mill again. This feature is objectionable, as these products have already been dried and sized, their return through the mill causing a waste of power and screening surface. It is always poor policy to return a middling product back over the same machine that first produced it. Such a process will eventually crowd the machine with middlings and, in order to prevent this, the grade of the finished products must be lowered. If necessary, the middlings should be separately heated again and re-treated on middling machines placed beneath the regular machines, the different sizes being treated on their respective machines. Any middlings made on these last machines would either be negligible, or, if returned through the reheater again, would be so small in amount as not to interfere seriously with the separation. Other changes would be necessary to meet local conditions, but in all cases the general arrangement of the mill would be similar to that shown in the diagram.

The Huff electrostatic process was originally introduced on zinc ores and the separation of blende from pyrite is still its broadest field of usefulness. It must not be thought, however, that this separation is only adapted to such materials. Practically no limitations can be placed with regard to the minerals treated provided they possess a sufficient difference in electrical conductivity. The process has already been successfully tried on many types of minerals, some of which might be mentioned here: Zinc, lead and iron middlings; chalcopyrite in quartz; pyrite and chalcopyrite in various gangues; chalcopyrite and bornite in granite; zinc, iron and silver ores; native copper in sandstone; pyrite concentration for sulphur; silver ores from a quartz gangue; molybdenite from gangue minerals; mica from graphite flake; slate from coal, etc. Electrostatic mills are now in successful operation in several places in the United States and a few in foreign countries. A broad field has already been opened to this process and the future will no doubt extend its scope.

Panama and Suez Canals

THE following table is interesting, as it shows the number of vessels using the Panama and Suez canals for the months of August, September, October, November and December:

	Panama.		Suez.	
	No. of Vessels.	Net Tonnage.	No. of Vessels.	Gross Tonnage.
August	24	106,258	250	1,402,864
September	57	322,038	328	1,721,195
October	84	420,357	479	2,635,446
November	92	448,801	370	2,625,446
December	99	489,915	397	2,451,424

An analysis of the traffic through the Panama Canal for the six months of commercial operation ending on March 1st, as prepared by the canal officials, is as follows:

	Panama.	
	No. of Vessels.	Net. Tonnage.
United States coastwise, east-bound	97	499,439
United States coastwise, west-bound	109	493,272
United States Pacific to Europe	66	444,855
Europe to United States Pacific	16	59,516
South America to United States and Europe	69	378,386
United States to Europe and South America	31	128,922
United States Atlantic to Far East	48	287,782
Far East to United States Atlantic	2	14,500
Miscellaneous routings	13	60,572
Vessels without cargo	45	.....
Total	496	2,367,244

It will be seen that 496 vessels have used the Panama Canal during this period of its use, and have paid in tolls about £410,000. An American contemporary says that the canal is now largely a domestic enterprise, and that when the war is over and the commerce of the world can be resumed, the career of the canal as an international institution will begin. Then will it be known whether the enterprise will earn interest on the money expended in building it.—*The Marine Engineer and Naval Architect.*

Effect of Acetylene on Metals

ONE point in connection with the use of acetylene, to which too little attention has been given by makers of apparatus for producing and using the gas, is its corrosive effects on some metals. Tests have shown that moist acetylene, as generated, attacked zinc, lead, brass and nickel to a slight extent; iron was affected at about six to seven times the rate; phosphor bronze about twice as much as iron; but copper suffered more than any other metal tested. Copper was quickly changed into a soft, porous black mass. Tin, aluminium, bronze, German silver, and solder were practically unaffected. Thus, it would appear that copper and brass or other copper alloys should not be used as piping for acetylene gas supplies, and that iron should be well tinned rather than galvanized or nickel-plated.

Artificial Light Treatment of Surgical Tuberculosis*

A Substitute for Sun Baths That Promises Valuable Results

Much success has been gained in the treatment of surgical cases of tuberculosis by means of sun baths in high altitudes, a curative method developed especially in continental Europe. The remarkable results attained, particularly by Bernhard at Samaden, and Rollin at Leysin, have led many distinguished European surgeons to recommend sun baths in high mountain regions as the best treatment for their patients. There are, however, two difficulties which will always limit the number of patients taking such a cure: the length of time required, for the effect of the sunbaths is a gradual one, and the expense.

Sunbaths at altitudes nearer sea-level are said to yield good results, yet not equal to those of high regions. A cloudy summer with only intermittent periods of sunshine, as sometimes occurs in various European countries, makes the treatment in lower altitudes difficult. Dr. Bardenheuer of Germany, reported good success from a systematic treatment of surgical tuberculosis during the Summer of 1911, but the cold Summer of 1912 did not yield the results of the previous warm one. In the lower levels also sunbaths are more trying than in higher altitudes; probably on account of the greater atmospheric pressure, the patient is more easily fatigued, the danger of prostration from heat is increased. There is lacking, further, in the lowlands the favorable influence of the rarefied atmosphere upon the circulation of the blood and the excretory processes of the skin.

The economic difficulties attending the cure in high regions, and the physical difficulties surrounding sunbaths in the lowlands led to the attempt to replace the natural sunlight of high altitudes by an artificial light which could be used in treatment at lower levels.

An interesting account of this treatment with artificial light, written by Dr. Richard Hagemann, first assistant of the surgical clinic at Marburg, Germany, appeared some time ago in the *Deutsche Medizinische Wochenschrift*, the article being the publication of a paper read by Dr. Hagemann before the surgical society of the Middle Rhine.

In discussing his subject Dr. Hagemann says that the violet and ultra-violet rays, that is, the short-wave chemical rays, are considered the most effective principle in the sunlight of high altitudes. Consequently, it was the most natural to use these rays in the therapeutical experiments. These rays are produced by the electric arc-light, the Fensen-Reyn lamp, the iron-electrode lamp, and especially by the mercurial vapor lamp that is manufactured in various forms. All these artificial sources of light have been used with good effect in the form of local applications, generally only for external affections and especially for tuberculosis of the skin. The influence of the ultra-violet rays upon these external troubles, and only upon these, is perhaps most easily explained in this way: that where the rays come into contact with the tissues they excite a reactive hyperæmia, and that they are not able to penetrate deeply into the tissues. These effects were confirmed by Dr. Hagemann's own investigations.

"We used the Bach-Nagelschmidt quartz lamp," continues our author, "which yields more than a sufficient quantity of chemical rays and which is not difficult to manage for prolonged processes. Thirty-one patients were locally treated by the rays of this lamp between August, 1912, and June, 1913. These cases were first purely external diseases of the skin, tuberculous or non-tuberculous in character; then treatment was also given to open diseased tracts, fistulas, and diseases of the glands which extended deeper, and especially to tuberculosis of the bones and joints.

The experiments showed that external processes, granulating wounds, lupus, and other forms of tuberculosis of the soft parts, were almost always favorably affected, sometimes cured. Local treatment with the rays of the quartz lamp had also at times a noticeable effect upon tuberculous glands of the neck, but often they failed to cause improvement. Failure was generally the rule in tuberculous processes of the bones and joints that lay still deeper, fistulas being also connected at times with these processes; as a rule the rays caused no improvement. There was, however, one unusual cure: that of a man 65 years old with tuberculosis of the knee and ankle. The knee-joint was resected but a fistula remained; there was also a fistula near the ankle-bone. Fenestrated plaster bandages were applied and local applications of the rays were made. After fourteen treatments given within three months the fistulas closed and remained closed. This rapid cure of a man 65 years old is remarkable and apparently should be ascribed to the rays. The case, however, as already said, stands alone; in other cases of tuberculosis of the bones and joints local treatment with the rays was not in any way successful."

So the results do not correspond to those attained by local irradiation by the sun, by Bernhard at Samaden, for example. The reason for this lack of success is in the merely superficial effect in local application of the short-wave rays. Therefore, the quartz lamp in such use is no substitute for the sun of high altitudes.

Rollier always emphasizes in replying to critics that his greatest successes are attributable to the fact that he exposes the entire body to the rays, while his opponents uncover only the diseased tract to the sunshine, keeping the rest of the body covered. In Dr. Hagemann's opinion there is an essential difference between general and local irradiation by the sun. In the one case a hyperæmia is caused by the influence of the light and a bactericidal effect is gained upon the surface, in the other an effect is produced upon the entire surface of the skin, the entire circulation of the blood, the whole metabolism. In the purely local treatment the diseased area is directly attacked, similarly to the action of the Roentgen rays, although these latter are the more penetrative. In the general method the whole body is brought under treatment, its exhausted powers aroused, and these act upon the local center of disease. Consequently, it may be said, that in the general exposure to sunshine there is only an indirect effect exerted upon the local process. On account of this difference in the method of producing effects, it follows that better results can be obtained from a general irradiation by a quartz lamp than by a local irradiation. Moreover, the general exposure to the rays is more in harmony with the fact that tuberculosis is always more or less a general disease.

A general exposure of the body to the rays of the quartz lamp has also been used by some physicians, as Bach, especially in disorders of metabolism. In such cases a favorable effect upon the general condition has been shown, the cause of which is the improvement of the general metabolism. No injurious results have been observed. For these reasons Dr. Hagemann considered himself justified in using a regular and systematic general exposure to the rays of the quartz lamp in cases of surgical tuberculosis.

"This quartz lamp," he goes on to say, "is to replace the natural sunshine of high latitudes. Theoretical considerations showed me at once that it could not be a substitute of equal value. The quartz lamp yields only a single, though perhaps the most effective, group of rays, namely the short-wave rays. According to the theory of Rollier and his collaborators the formation of the main pigment is due to the short-wave rays alone, and they measure the main effect of the general irradiation by the formation of this pigment. How does this pigment act? According to recent investigations it appears to be settled that the pigment forms not only a protection against the toxic effects of the chemical rays of light but also transforms the short-wave rays into long-wave rays, therefore into red and ultra-red or heat rays, which, in turn, penetrate more deeply. So the pigment to a certain degree acts as a sensitizer for the long-wave light. The actual curative effect, therefore, should not be ascribed to the short-wave rays but to the warm light rays. Investigations by Frankenhäuser, Finsen and others have shown in regard to the red rays of light, which are the heat rays, that they are able to penetrate much more deeply into the tissues than the violet and ultra-violet rays, that they develop heat in the depth to which they penetrate, generating hyperæmia there, and consequently have a much more extensive effect than the violet rays. According to Wiesner the red rays in addition have much greater bactericidal force than the violet rays."

Consequently the question arises whether the ultra-violet rays really play so decisive a part in heliotherapy, and whether an important effect should not also be ascribed to the other groups of rays contained in sunlight. From a therapeutic point of view, therefore, Dr. Hagemann decided that it was injudicious to select a single component of sunlight, even though a very effective one. So he used electric incandescent light in addition to the quartz lamp. First, red carbon-filament incandescent bulbs were used, then ordinary white ones of the same kind, which give the same red light rays and other groups of rays besides.

He believes that in the action of the red rays he obtains the second essential factor in the sunlight treatment. An important therapeutic effect is attributed to heat in all inflammatory processes, especially in tuberculosis, so why should not the heat rays also be of value in exposure to sunlight? It is known that red light hastens the re-absorption of exudations. Kuttner and Laqueer have described their researches on this point. Moreover, the heat rays cause a decided dilatation of the blood-vessels of the skin, brought about by hyperæmia of the skin, that appears during the irradiation, and, further, more energy is conveyed to the blood by the violet rays, whereby the influence of the violet rays can be increased.

In the cases treated, Dr. Hagemann considered that the patients exposed to the combined light were more quickly and deeply pigmented than those exposed to the quartz light alone. The combined light, the patients said, was also more agreeable to the body. Indeed, they generally grew unwilling to be exposed to the light-bath unless the incandescent light was also used. The combined light, as the doctor personally found, felt more like a genuine sunbath. The body was pleasantly warmed through, and there was a slight perspiration, neither of which symptoms appeared when the quartz lamp alone was used.

The simultaneous application of the heat rays along with the violet enables the physician to make use of a third and very important factor in the sunlight treatment, that is, the exposure to the rays in the open air. All physicians who use the sunlight treatment lay great stress upon the effect of the open-air bath, even allowing the patients to lie unclothed in the open air when there is no sunshine. Bernhard, who only uses a local sunshine treatment, ascribes the rapid improvement of the general health to the open-air cure alone. Equipping the quartz lamp with electric incandescent bulbs makes it possible to use the light treatment in cool, well-ventilated spots, verandas, and perhaps also out of doors, for, even when there is a continuous current of fresh air, the heat under the lamp itself can be easily regulated and kept at a constant temperature by switching in stronger or weaker incandescent lights.

In all Dr. Hagemann treated 52 patients by a general exposure to the rays. The treatment began in January, 1913, so that at the time of his report it had continued five months. The cases were largely tuberculosis of the bones and joints, both closed and open, fistulous and of mixed infection; there were also patients with chronic osteomylitis. The exposure to the rays first caused an erythema of the skin that lasted two or three days, then the pigmentation of the skin appeared. This pigmentation is exactly the same as that of sunbaths, some of the patients looking like Moors. In this method of treatment the amount of pigmentation varied in blondes and brunettes, in the stronger and weaker patients, a fact also observed by Rollier in the natural sunbaths in high altitudes. The patients who reacted with a deeper pigmentation improved more rapidly than the less pigmented. The first noticeable symptom of improvement, that regularly appeared, was a decided increase of the appetite. Children who previously had to be forced to eat, asked themselves for more food. The increase of appetite is the first improvement noticed by the parents of children treated by exposure to the rays at the polyclinic, and also by the older patients themselves. A good effect upon the sleep was also noticed. Patients generally have broken sleep and scream at night, but after exposure to the rays the sleep is more quiet and refreshing at times for a continuous period. Perhaps the reason for this, in part, is that the pain suffered by the patients disappears very rapidly, a phenomenon to which Rollier has also called attention in the sunlight cure. The improvement in general health is most clearly shown by the increase in weight which is often considerable. Gain in weight is not always in itself a proof of improvement but Dr. Hagemann considers that it showed the effect of the rays in the cases treated, because the increase appeared regularly in all cases, especially in those that had already for a long time been receiving the usual treatment under his care, and in which cases nothing was changed, except the added exposure to the rays. The increase of weight was also noticed in patients at the polyclinic, who did not change their mode of life but went on with their ordinary occupations. When a patient who has gained only one kilogramme in four months suddenly gains another kilogramme within a month after the beginning of the irradiation cure, without any other change of treatment, and the gain of this amount continues for four successive months, then the increase in weight is certainly to be attributed to the light treatment. Several of such cases occurred.

Along with the increase of weight the appearance of the patients improves, the face has a fresher, entirely different expression, the turgor of the tissues returns, a layer of fat is formed, the flabby muscles grow firm. The patients, especially the children, are much livelier, and more amiable. They sing as they sit under the lamp; in short, it is evident that they felt well. These are phenomena so similar to those noticed in the treatment by sunlight in high altitudes, that the deduction

* *Deutsche Medizinische Wochenschrift.*

drawn from the effect of the sunbaths in high altitudes can be applied by analogy to the presumable results of the artificial light treatment.

The strengthening effect of the treatment is not only seen in cases of tuberculosis, but also in other troubles, as chronic osteomylitis. This shows that the light cure has no specific effect upon tuberculosis, but that its influence is only a general, strengthening one, yet, however, to so great a degree that it far exceeds all former methods in increasing vigor.

At first the local symptoms improve gradually. The light rays do not directly affect the diseased area. Primarily they act indirectly by improving the general health, by increasing the bodily vigor. In this particular the treatment by natural sunlight has exactly the same effect as that by artificial light. Many months are required by Rollier's method also to heal fistula. When the trouble is open diseased areas, or fistulas the local action is first an increased secretion, then its diminution, and lastly the healing begins. Swellings of the extremities, infiltrations of the soft parts, surrounding the diseased areas decrease, the joints are once more flexible, exudations are reabsorbed, cold abscesses disappear.

As far as possible all other methods of treatment were suspended, the physicians limiting themselves almost entirely to keeping the limbs motionless in extension bandages, splints, etc., even punctures of the joints and iodoform-glycerine injections were avoided, in order to reach a decision in regard to the treatment by artificial light to which as little exception as possible could be made. Dr. Hagemann's opinion, however, is that this method is by no means the normal procedure, but that the combination of the light cure with the customary general or local methods would give the best results. In the artificial light cure the main work falls upon the body itself, and this labor should be made as easy to the body as possible. Therefore, punctures with iodoform-glycerine injections, curetting, and even resection and amputation are justified under present conditions, although their need perhaps would be essentially limited. The improvement of the general state of health is thus of the utmost importance in opening the way for a cure by the use of tuberculine, it also prepares a better basis for medicinal therapy. In particular, the reabsorption of exudations and cold abscesses is hastened by the use of iodide of potassium. One striking advantage of the artificial light treatment is that it can be used in winter when there is less sunlight, and on rainy days, so that there are no long interruptions of treatment which oblige the patients to start at the beginning again.

Long continued or severe injurious effects were not observed in the artificial light treatment. The sole injury arose chiefly in the early days of the cure before knowledge had grown through experience. This consisted of small heat-blisters in sensitive spots. Such hurts, however, can be avoided by careful use of the necessary precautions.

The method used by Dr. Hagemann is in detail the following:

"In the local exposure to the light," he says, "for which formerly the quartz lamp alone was used, the quartz burner was placed 30–40 cm. from the surface to be irradiated. The parts surrounding the exposed surface must be carefully covered in the same way every time, otherwise the intensive effect of a lamp so close would burn severely the unprotected parts which are exposed all at once to a prolonged irradiation. Caution must be used in accustoming the skin to the light. The first exposure should not last longer than three minutes; in each succeeding exposure the time is lengthened three minutes until the longest period of exposure, half an hour, is reached, the treatment being repeated either daily or every other day. If, during an exposure to the light, a strong reaction appears (extreme reddening, œdema of the skin and blistering), the treatment must be dropped for three or four days, then cautiously recommenced with the last well-borne period of exposure. If the cure is omitted longer than four days, it is necessary to start from the beginning again. The best distance for a general exposure is 80 cm. to 1 m. The body is entirely uncovered, but the eyes must be carefully protected from the ultra-violet rays, otherwise there is severe inflammation. Ordinary snow-spectacles can be used, but they must come in close on the sides. I generally cover the whole face. For children any other method gives poor results, and it is besides an advantage not to let the face be burned by the rays. The natural color of the face remains and is an aid in judging the condition of patients. The covering of sensitive parts of the body, as the genitals, the flexure of the groin, and the popliteal space is not advisable, because it cannot be done uniformly. By proceeding gradually these parts can be accustomed to long-continued exposure to the light. The first exposure is for five minutes and only one side, either front or back, is exposed to the light. If this is borne without too great a reaction of the skin, on the next day both the front and the back of the body have the light thrown on them, first one and then the other side for five minutes each. The irradiation is then prolonged five minutes for each side at each succeeding treatment, until the treatment is continued for two, three or even four hours, one half of the period being assigned to one side. The treatment is given either daily or every other day, the latter mainly in the cases of weak children or of polyclinic patients who, on account of their work, cannot come every day. A longer intermission in the treatment with light should be avoided, as otherwise the skin will become very sensitive again, making it necessary to start afresh from the beginning. There is always a slight erythema at first. If the erythema is pronounced and the burning and twitching worry the patient, the treatment must, at times, be dropped for several days and much caution used when the exposure to the rays begins again. Little reddish-blond children who have naturally a tender skin are the most difficult cases to manage in this particular, especially if they wet themselves during the exposure to the rays. The skin must be kept dry, otherwise it is more easily burned. If the patients feel a severe burning during the treatment, then the latter must be suspended. There must also be the same suspension if there are indications of heat prostration, headache, nausea, vomiting, or unconsciousness. I have never seen such phenomena in exposure to artificial light, but they are theoretically possible. The patients should rest for a time after the treatment, although as a rule they do not feel tired, at least after they have been treated several times. They generally fall asleep during the irradiation and are afterward fresher than before."

Several patients were generally treated at once, as eight children or three grown persons. In such cases it has been found best to shift the positions during the exposure, because the effect of the rays is less at the edge of the field of light on account of the greater distance of the lamp.

The patients were placed either on two beds that were set together, or, better, on low ordinary wooden tables, above the center of which the quartz lamp hung on a cord that ran over a roller on the ceiling, so that it could be easily raised or lowered. The tables were covered with mattresses or with soft coverings. Cellulose cushions were placed under discharging wounds to prevent soiling the bed, otherwise the wounds needed no particular care, but were freely exposed to the rays. In a case, however, of a clean, granulating wound which was about to form an epithelium, it was considered desirable at times to cover such a spot, as there is occasionally danger that the rays may injure the fresh epithelium. As a rule, though, the rays have a stimulating effect upon the growth of the epithelium.

Dr. Hagemann used the Bach-Nagelschmidt quartz lamp called the artificial sunlight of high altitudes, which he obtained from the company manufacturing such lamps at Hanau-on-the-Main, at a cost of 290 marks (about $72.50). A ring holding eight 50-candle carbon filament bulbs was arranged around this quartz lamp at an extra expense of about 80 marks (about $20). An hour's use of the rays cost about 40 pfennigs (about 10 cents). The company at Hanau manufacturing the quartz lamp have made from Dr. Hagemann's specifications a modified form of the quartz lamp in which the ring for the incandescent bulbs forms a part of the lamp fixture, making the whole equipment simpler and more practical in actual use, for it can throw the rays over a larger surface.

The treatment just described was given to a comparatively small number of patients and the report was made not long after the cures had been effected. Yet the results of the treatment with artificial light of surgical tuberculosis are so striking that Dr. Hagemann seems justified in considering artificial light a substitute for the sunlight of high altitudes. The advantages of the artificial light treatment are simplicity, cheapness and suitability for use anywhere, so that the poorest patient can receive its benefits. These advantages give the artificial light treatment greater economic value than the treatment by sunbaths in high altitudes.

Practising Economy

In transacting their internal business many American railroads are obliged to use heavy envelopes of large size for transmitting papers from one department to another, and this entails considerable expense. As it is not usually necessary to seal these envelopes, and they are, therefore, not subject to mutilation, it has been found possible to use these envelopes a number of times; and to facilitate the process, and to insure the economy, lines are printed on the face of the envelope for a dozen addresses, each being crossed off after it has served its purpose. A considerable saving has been effected in this way, as envelopes of the kind referred to are fairly expensive.

Reducing valves which are too large for the amount of steam they are to pass are usually unsatisfactory, states *Power*. Either they will open and close continually and chatter violently or will stand in a position nearly closed and become steam-cut and leaky. It is more satisfactory to use two small valves in parallel, one set slightly heavier than the other, so that one will supply steam up to its maximum capacity before the other opens. Another way is to use one reducing valve equal to about one half the maximum demand, and a by-pass of about the same capacity with a hand-operated valve in it, so that when the reducing valve reaches its capacity the by-pass valve may be opened wide and the reducing valve will close down and simply make up the shortage. This, of course, requires that an attendant shall observe the pressure gauge occasionally.

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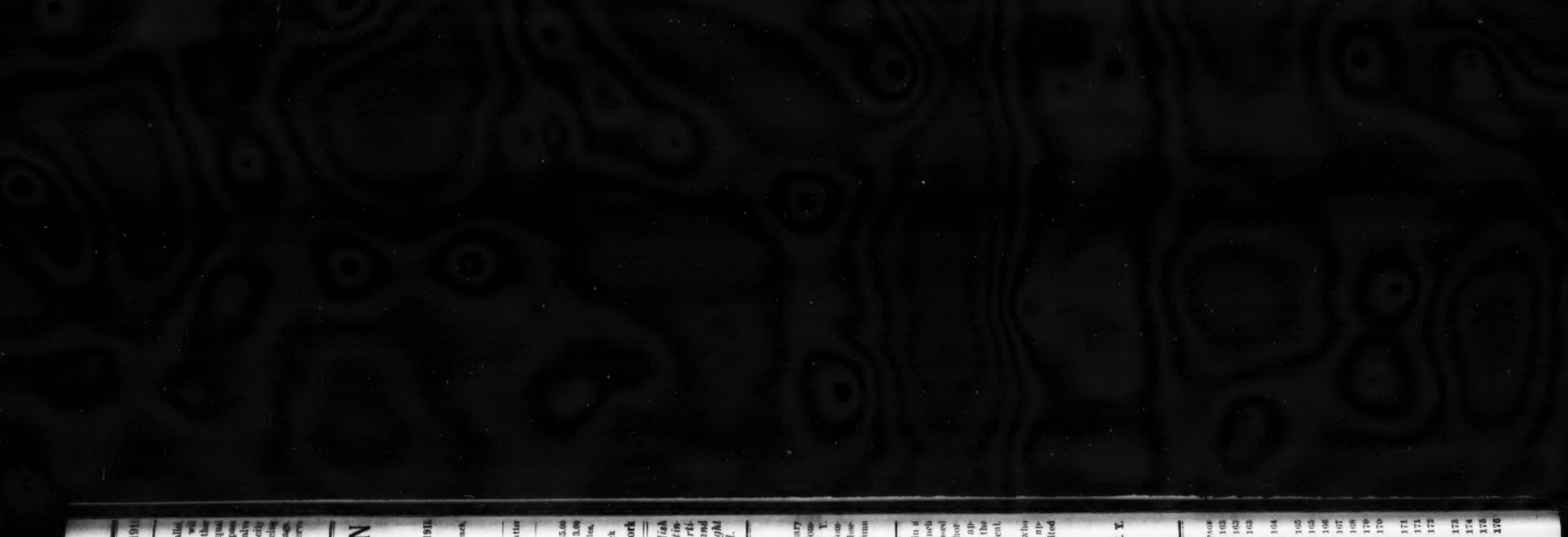
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